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A Human Factors Philosophy

LAURENCE E. MOREHOUSE, Professor of Physical Education, University of California, Los Angeles.

It is the nature of man to want to know more about himself and the world in which he lives. He is continually discovering things about himself and his world. Being rational, man attempts to relate his new-found discoveries to things he already knows. In so doing, he develops bodies of knowledge and also methods of study which are peculiar to the area of investigation. Together these become a discipline, or a science. As man's discoveries expand new disciplines are born, and man attempts to fit these into a systematic organization of his knowledge.

The study of the human factors in the man-machine-environment system is producing a fast-growing body of knowledge, and entirely new methods of study are being devised to keep pace with the explosive development of man's ability to manipulate nature. In this study, in which cross-fertilization between life sciences and engineering is encouraged, the human factor is considered in relation to the machines and environments in which man works and plays. The ultimate aim of each human factors effort is toward the optimal utilization of human and machine capabilities to achieve the highest degree of effectiveness of the total system.

The human is the stable element in each system, since he does not undergo drastic changes. Although each advance in machines and environments will have a bearing on the human component, the essential principles governing human behaviour and performance capacity will not be altered. Thus, the elucidation of human factors principles is of everlasting benefit, and it is the purpose of the Human Factors Society of America and this Journal to contribute to the advancement of this knowledge.

Trends In Human Factors

JULIEN M. CHRISTENSEN, Chief, Engineering Psychology Branch Aero Medical Laboratory, Wright Air Development Center.

An attempt is made to define the metamorphosis of the human factors area since World War II. While excellent work has been accomplished on problems relating to the detailed design of systems components, there is a significant lack of information relating to the gross problems of systems design. The need for research in this important area is emphasized.

A plea is made for relating future work to the fine foundation that exists in the behavioral and biological sciences. The problems associated with one important area, space travel, are discussed from the point of view of solving them by extending investigations already completed or underway in relevant areas of the behavioral and biological sciences.

The problem of applying available principles to actual design problems is discussed. Investigations that would disclose the generality of the basic principles already available would be of enormous benefit to those engaged in the application of human factors knowledge to the design of components and systems.

INTRODUCTION

The character of human factors work has changed over the past decade. This metamorphasis is continuing, and it may be of interest to attempt to describe and evaluate some of these changes.

Early human factors investigators generally attempted to establish principles which could be applied directly to the solution of detailed design problems. For example, considerable effort was devoted to investigations regarding optimum shape, size and direction-of-actuation of hand controls. Equal attention was given to the design and lighting of visual displays. Some researchers investigated optimal control-stick displacements and pressures, while others were interested in traditional anthropometrics and functional sizing, limits of reach and manipulation, etc. Much was accomplished in communications research with respect to factors such as redundancy, content and carrier. A limited amount of effort was devoted to designing training devices so as to yield maximum positive transfer from the training to the operational situation. These investigations generally were performed in accordance with sound scientific procedures and traditions, and form a basis for this field for which no one needs to apologize.

LIMITATIONS OF THE EARLY WORK

Implicit in much of this early work, i.e., selecting fairly restricted segments of a complex system for detailed investigation, were several assumptions and problems that seemed to establish themselves as reverberating circuits in our nervous systems. It was recognized that eventually these must be confronted.

First among these was the assumption that improvements in detailed design ("knob and dial work," as it has been loosely termed) would, when summed, yield worthwhile gains. The possibility of decrement, or at least no significant improvement, due to unmeasured and unanticipated interactions, though apparently recognized, often was neglected.

Second, frequently the experimenters employed subjects whose representativeness with respect to those who would use the operational equipment was not known. Here again was a variable that could produce changes in qualitative or quantitative relationships.

Third, important dimensions of behavior had been omitted intentionally, or, at least, had not been controlled systematically. Generally this was due to the paucity of information available regarding the definition, measurement and control of these variables. Examples are available from such areas as motivation, stress, and fatigue.

Fourth, and finally, was the familiar, omnipresent criterion problem. What are the reliable and valid ultimate criteria of component and system effectiveness? Are there valid intermediate criteria that are sufficiently sensitive and isolable to enable one to gauge the effectiveness of changes such as those described above?

Meanwhile, those engaged in making recom-

mendations regarding actual design problems were encountering challenging conditions. The most common complaint concerned the timeliness of human factors recommendations. Retrofitting is a time-consuming and costly procedure, and those engaged in applied work frequently found themselves consulted so late in the development cycle that the desirability of incorporating their suggestions was mitigated by funds and time.

Second, applied people were understandably anxious regarding the limits to which one could extrapolate from much of the experimental data available in the biological and behavioral sciences. Suprisingly little information is available in the literature regarding this important problem of generality.

PRESENT AND FUTURE TRENDS—

The criterion problem probably never will be completely resolved; however, there are several programs that show considerable promise in their attack on this important aspect of our work. Fitts, et al [1] have suggested the following five criteria of effectiveness for human factors contributions to equipment and systems design:

1. manpower
2. training time
3. efficiency
4. safety
5. user acceptance

Somewhat related to these, but deserving specific mention, are such criteria as dollar cost, time (delay of design and/or production), ease and efficiency of maintenance and ground support, and maintenance of the proficiency of operator and ground support crews.

The issue that must be faced, however, is even more complex. It is this: What are the relative weights or values to be assigned to these and other relevant criteria? For example, how many units of performance are we willing to sacrifice to gain a specified number of units of safety? How much additional time are we willing to devote to training in order to be able to operate and maintain systems with a specified degree of higher performance? Obviously, these relationships are characteristically multidimensional. What, for example, are the quantitative relationships among safety, training time and performance? It will be a notable advance when we are able to present our findings in this "trade-off" manner.

These, and other considerations, have stimulated investigations in "systems research." Those concerned with systems research seek fundamental principles governing the behavior of systems. They are attempting to develop methods for evaluating system performance in terms of these principles. Systems research requires the concomitant consideration of as many system variables as necessary in order to assure validity and reasonable generality of results. (A nice problem in itself!) Such principles and methods, when fully developed, will prove to be powerful tools in the design of complex systems.

Aside from the criterion problem, systems investigators experience understandable anguish when they attempt to define those segments of the system that can be extracted and abstracted for consideration without vitiation of over-all results upon reassembling the entire system (the "partitioning" problem). Then, too, what constitutes an adequate description of a system? How can a human factors investigator be certain that the usual descriptions (communication links, communication content, subsystem functions, etc.) are adequate in terms of those operations of the system that are critical to his interests?

There is an urgent need for a comprehensive set of terms that defines the behavior of the human operator in systems. What, for example, is really meant by "decision process"? As yet there is no unified basis for classifying the various kinds of behavior in complex systems. Answers to questions such as these are needed to provide a firm semantic foundation for investigation and application.

There is a need for the development of theories of behavior applicable to complex man-machine systems. The concepts must be meaningful to and usable by the systems designer. The fundamental concepts not only should admit of operational definition for application to systems experimentation, but also should provide a link with existing behavioral knowledge, being, perhaps, at once unique but not foreign to the traditions of psychology and other behavior sciences. No new approach can afford to divest itself of the tremendous fund of sound behavioral knowledge that exists. Some, we fear, appear to be ready to do so.

Research in mathematical model-building with special emphasis on the solution of complex problems involving higher-order interactions is needed. This (mathematics) will prove to be our common communication medium with engineers, physicists and other scientists.

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These problems eventually will be solved by study and experimentation. Various criteria can be used and their suitability assessed. Some day someone will perform a factor analysis of systems criteria; the need for parsimony here is manifest. The experimental approach can be used to solve the partitioning problem simply (we *don't* mean it will be simple to do) by treating it as an independent variable. Finally, various methods of description will disclose their degrees of adequacy, and be retained or discarded on that basis. In addition, systems investigators hope to produce meaningful and useful results not only by experimentation, but also by employing such tools as logical analysis, mathematical model-building and systematic observation. The challenge is awesome, but the rewards will more than justify the efforts.

If these suggestions sound trite, we beg your indulgence. However, too many people figuratively throw up their hands in despair when systems research is mentioned. In addition to the problems mentioned previously, these people remind us of the problems associated with gathering and analyzing enormous amounts of data, the expense of such operations, etc. These problems are indeed real and important. However, virtually no one suggests that the aims of systems research are invalid or that solutions would not be worthwhile. Fortunately, there are already some tools that can be used and others that show promise—mathematical models, high speed computers and complex simulations, to mention a few. What is needed most are a few hardy souls who will try and, even though they fail, thus make it possible for the less venturesome more intelligently to direct their efforts.

Fortunately, there are several groups that already can point to positive accomplishments in systems research. The Systems Development Corporation and the Aviation Psychology Laboratory of The Ohio State University are examples of such groups. In addition to these efforts, in-service people at the Aero Medical Laboratory are attacking the problem with vigor and are gaining considerable insight that will be useful in establishing programs and in solving systems research problems.

Systems research has been considered first not only because of its importance, but also because eventually it may provide another criterion for the adequacy of the work in other human factors areas. Now let us consider some of these other areas.

General

First, consider the basic sciences upon which human factors specialists depend so heavily — psychology, physiology, anthropology, sociology and others. It is trite to say that more research is needed; we must be more specific. In addition to more basic data, however, we need desperately to know the generality of available data. How far and to what kinds of situations can we reasonably extrapolate from available information? The basic scientists might feel that this is a problem to which the human factors specialists should address themselves, and perhaps they are correct.

Now let us consider some research areas that are even more directly associated with design and development. (Some prefer to call this area of work "applied experimental".)

Controls

In the controls area modest success has been experienced in writing transfer functions for the human motor response system. Eventually this endeavor may enable design engineers to specify mathematically the process characteristics of the human when serving as a control unit, component or subsystem. Our laboratory already has successfully used such a formulation to predict points of instability in aircraft control systems. With our support, the Franklin Institute has concentrated on the derivation of a linear descriptive function, the remaining uncorrelated output being considered, at present, as an undefined remainder term. Serious work is required on the nonlinear portions of this and similar formulations.

Research is needed on human factors design criteria for remote handling devices. Information is needed concerning the behavioral effects of such factors as the nature and fidelity of feedback processes. Again, the generality of available principles is unknown.

Information is needed with respect to human performance when engaged simultaneously in an essentially continuous task and in auxiliary discrete tasks.

Information Displays

An immediate challenge in the visual displays area is the determination of not only "how" but also "how much". Mackworth [2] points out that modern computers not only can turn out impressive stacks of figures, but also can select and summarize. He feels that this characteristic of computers has not been adequately exploited. Mackworth proposes that we discover how *little* information must be recorded and processed in order to obtain a desired result, or, at least, how little finally to present to man for treatment. We would add only that the decision regarding

what information finally to present to man (thus determining what control he will exercise) will vary widely under different conditions. The trade-off curves referred to previously are probably quite different for an inhabited space ship and for a chemical plant.

In addition, more information is needed on the nature of sensory overload. Many have assumed that the limits in man's ability to receive and process information are defined by his visual scanning rate, the number of absolute or relative discriminations he can make, etc. Their suggested solutions, then, necessarily involve "relieving" the overburdened modality by displaying information to one or more of the other senses. But will this approach yield the best solution? Perhaps the true limits are defined by the cerebral cortex. If so, Mackworth's plea is even more poignant.

The visual perception of complex forms needs additional consideration. Particular emphasis should be directed toward quantifying those aspects of a form that make it discriminable from other forms. The engineer often can figure out a way to display solely, or at least to emphasize, those characteristics that enhance discrimination. We, however, must specify those characteristics.

The attention-getting value of various stimuli requires the determination of the characteristics (frequency, intensity, etc.) of those stimuli which are effective in redirecting attention from the primary task for various conditions of masking and primary task load. Differences in motivation almost certainly will be found to be of importance here.

The employment of infrequently used senses as channels for information input to the human operator needs attention. It is important to have information concerning the relative merits of different sensory modalities for receiving, processing and making various types of information available for further use.

Decision Making

Basic research is needed regarding the task variables involved in the decision-making process. The research might include such independent variables as the number of informational dimensions, the amount of information per dimension, the methods of presentation of the information and the number and kind of response alternatives available.

Training

Those assisting in the design of training equipment for weapon systems face fascinating problems. For example, how does one develop and train for expertness in monitoring and decision-making (functions man inevitably will be asked to perform more and more frequently in the future)? How does one transmit the knowledge of results that is so essential to efficient learning and continued motivation? How does one train a man so that he can maintain skill throughout long periods of monitoring?

Many feel that we need to create a classification or taxonomy of tasks and behaviors. Such a classificatory scheme for human behavior should facilitate the organization of existing information about those factors which influence the learning, transfer, and retention of specific behaviors, and should stimulate further research regarding those basic principles that will allow reliable generalizations from existing knowledge about conventional laboratory tasks to a wide variety of tasks — again the problem of generality.

We need to investigate the influence the learning of one task has upon the learning of a second task with various durations of time between the two. We need to determine how "time between tasks" affects some of the basic principles of transfer of training. For example, investigation of the influence of various durations of time between tasks upon the basic relationship between degrees of similarity and transfer of training is needed. The similarity should be obtained through various means and with different tasks, since similarity based on some features may be very resistant to the effects of time while similarity based on other features may be very susceptible to the effects of time.

A vast amount of research needs to be accomplished in order to determine the extent to which existing knowledge about learning, transfer and retention can be generalized to various conditions, tasks, subject populations, etc.—the problem of generality again. Some of the most important factors to be evaluated are complexity of the task, required speed of performance, degree of training, intellectual and motor content of the task, and ability of the subject.

Space Travel—An Important Applied Problem

There appears to be a tendency in some quarters to view the behavioral problems of space travel as so unique that we must develop virtually an entirely new system of description, prediction and control. We believe that careful analysis will disclose that we are dealing with the same fundamental dimensions, even though the points on some of these dimensions may be extended beyond present measurement. And let us not forget the possibility of altered interactive characteristics as we extend our measure-

ments to points on these dimensions that have not been considered before.

Some of the specific dimensions requiring additional treatment appear to be these:

1. Effects of sub-gravity conditions on man's behavior. What are the effects of the weightless state on man's performnace? What are the effects, both physiological and psychological, of exposure to a gravity less than one? It is probable that motor acts will be disrupted, at least temporarily, and it is not inconceivable that higher thought processes will be disrupted — the importance of proper motor adjustment to mental activity will receive an interesting test in space and on the moon or Mars.

2. Effects of increased gravitational forces on man's performance. Investigations are needed concerning man's ability to perform under these conditions. Most of the available information stresses primarily the physiological limits.

3. Display of information in space vehicles. Some of the conventionally displayed parameters (e.g., attitude) have no literal meaning in space. However, orientation with respect to points of reference that have, or can be made to have, meaning to the operators will be necessary. Exactly what will be required is a point for serious study.

4. Duties of space crews. In addition to the informational requirements, a careful study of the nature of the duties of space crews is needed. How much design can be eliminated with man in the vehicle; i.e. in what ways can he enhance system reliability? How can we best take advantage of his unique powers of judgment, decision-making and complex perception? In our opinion, those who feel man can perform no useful function in a space ship display a rather limited knowledge regarding the unmatched qualities this component possesses.

5. Space suit design. Studies need to be performed on the nature and amount of restriction imposed on man by protective suits usable both within and without the vehicle. These studies must be performed for long durations to permit extended absence from the space vehicle.

6. Long periods of confinement. Living quarters in a space vehicle will necessarily be small and confining. Information is needed regarding the behavior and interrelationships of small groups during long periods of confinement — an environment that may be essentially noiseless, gravity-free, and detached. The importance the social psychologists place on "frame of reference" and "anchorage points" must not be overlooked.

7. Diurnal cycles and behavior. In space, time zones are measured in astronomical rather than earthly time. Information is needed concerning the effect of serious disruption of the diurnal cycle on behavior. Preliminary work in our laboratory indicates this may be very serious *for some individuals* —we may be able to take advantage of what appear to be rather dramatic individual differences with respect to this and other problems. The only alternatives are training for unaccustomed diurnal cycles or adherence to earthly schedules regardless of the schedule of the planet one finds oneself on.

8. Training equipment requirements. In the near future it appears that the traditional method of employing a combination of in-flight and ground training will be impossible. The space ship operator will have to be trained to do his job perfectly before he ever goes into space, and he may have to perform without an instructor monitoring his first flight.

9. Other primary needs. Long-term space travel to be successful must give adequate consideration to such basic problems as food, water and sex. Our Laboratory is making commendable progress on the first two; everyone seems timid about discussing the third.

However, after the initial adventures are over and space travel becomes a routine, arduous job, we feel husband-wife teams should be considered in constituting the crews of long-range space ships, and certainly for the inhabitation of planet or moon colonies.

These nine points are not meant to be exhaustive; however, it is felt that the list includes some of the more important problems apparent to us now. Initial probes will disclose others; space travel won't be done easily, but it will be done.

These points also place what some would consider a disproportionate emphasis on behavioral as contrasted to biological problems. This was done knowingly. While first attempts must, and surely will, place most emphasis on keeping man alive and safe, the eventual goal must be to utilize man as effectively as possible. Sentiment is not a suitable criterion for employment of man in a space system or any other

system. Unless he can "pay his way" as we expect of every other component, he should not be used. Our predilection is that man will prove to be, as he has in other complex systems, an exceedingly effective sub-system—the sub-system that distinguishes an outstanding system from one that is mediocre. This will be true only if the designers realize the full value of men in systems, and we are the people who must appraise them of these capabilities.

PRESENT AND FUTURE TRENDS—APPLICATIONS

After considering the current state of our knowledge you may justifiably feel that those engaged in applying such information require not only intelligence, knowledge and resourcefulness, but also an abundance of courage and a high level of tolerance for frustration. There are problems other than those concerning basic information, however, in the application of human engineering data.

Of initial importance is the previously mentioned problem of timeliness. Human factors contributions must be consonant with the development schedule of a system. The Aero Medical Laboratory had the American Institute for Research develop a procedural guide for design and human engineers [3]. In this document Van Cott and Altman trace in detail the development schedule of an Air Force weapon system. They enumerate those stages in design at which specific human factors decisions must be made, and they describe the information that must be available to make such decisions.

Somewhat related to this point is the responsibility human factors applications specialists must bear for their decisions. It should be identical to that which any staff expert has to the chief design engineer. The days of offering advice from a cloister are, fortunately, almost at an end.

The human factors specialist must maintain a broad perspective with respect to the ultimate criterion—systems effectiveness. He must recognize and constantly remind himself that this refers to all aspects of the system—ground support, maintenance and personal utilization as well as efficient operation.

Finally, as yet there is no adequate handbook of human factors information that is usable directly by design engineers. However, the three services soon will publish a guide which will represent the most comprehensive source of materials available on design problems relating to controls, control dynamics, displays, anthropometry, workplace layout, etc. It is intended primarily for an audience of design engineers and secondarily for human factors specialists. However, it is hoped that no design engineer will accept this or similar materials without a human factors specialist's interpretation and advice. Dr. Spock's baby book has not made obsolescent the services of pediatricians!

CONCLUSIONS

Human factors considerations must receive adequate and timely attention if modern systems are to be maximally effective.

Research is needed especially in the areas of systems design and structure, training equipment design, ground support, and the effects of special conditions on behavior such as those to be found in space travel. An enormous amount of work needs to be done to define the generality of much of the existing basic data in both the behavioral and biological sciences.

Information is needed that will enable the generation of "trade-off" curves. Experiments must provide for the expression of results as functional relationships. That A is better than B is not adequate; how much better is it over the entire range of independent values?

The human factors applications specialist must take a continuing, active interest throughout planning, design, development, testing and operational use of systems. He must assume his fair share of the responsibility for the success or failure of this very complex undertaking—the creation of modern man-machine systems. The realization that he has made a significant contribution to such an undertaking should constitute ample reward for his efforts.

REFERENCES

1. FITTS, P. M. (ed) Human engineering for an effective air-navigation and traffic-control system. ANDB report prepared for National Research Council, March 1951.

2. MACKWORTH, N. H. Work design and training for future industrial skills. *J. Inst. Prod. Engrs.*, 1956, 55, 214-218.

3. VAN COTT, H. P. and ALTMAN, J. W. Procedures for including human engineering factors in the development of weapon systems. WADC Technical Report 56-488, Wright Air Development Center, October 1956.

Man As A Monitor

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The use of the feedback principle in monitoring as well as in continuous control situations is proposed. A simple feedback model is discussed and the associated variables identified. These include frequency of observation and response, sensitivity, time constants in feedback and control and reversibility of control. Ten monitoring or vigilance experiments are analyzed in terms of the model.

The relatively recent requirement for human factors information to be used in the design of well-integrated man-machine systems has not been very well satisfied by the existing psychological data [7, 18]. The shortcoming seems to stem from the fact that psychologists were not faced with a demand for data on man-machine relationships prior to World War II. Until that time experimental psychologists concentrated on the behavior of the organism and made a conscientious effort to keep the experimental environment as simple as possible. The stimulus-organism-response (S-O-R) and more generally used stimulus-response (S-R) paradigms illustrate this conceptual tendency of the psychologist to isolate the behavior of the organism from any environmental events which do not impinge directly on it. In both models the organism (O) is placed, explicitly in the former and implicitly in the latter, in the middle of a causal chain between the stimulus (S) and the response (R). S and R are energy forms past or present which, in the first case, act directly on the organism or, in the second, are initiated by it. The environmental process set off by R is not accounted for within the framework of either model except for particular events in the chain which act as new stimuli to the organism.

To explore the scope of behavior of the organism, the psychologist adjusts the stimulus milieu systematically but without too much concern for plausible environmental situations. One environmental feature often deleted is the sequential dependency of subsequent stimuli on the organism's response. This has received limited recognition through the addition to the S-R model of the concept of the "R-produced S".

$$S_1 \rightarrow R_1$$
$$\downarrow$$
$$S_2 \rightarrow R_2$$
$$\downarrow$$
$$S_3 \rightarrow R_3$$

However, this qualitative statement of the R→S relationship while adequate for the specialized interests of the psychologist, is not sufficient for the more comprehensive analysis of man-machine systems in which system performance is the focus of interest and in which a complex physical system mediates $R_1 \rightarrow S_2$.[1] The R-produced S notion describes only one instant in time. Each new R calls for a new statement of R→S, no equation summarizes the relationship. A rational adjustment of all the factors in the man-machine system to obtain the best system performance, calls for an analytical description of the $R_1 \rightarrow S_2$ relationship in terms comparable to the description of the S→R relationship, that is, an account of the environmental process (P) that relates R_1 to S_2, just as O represents the psychological process that relates S_1 to R_2.

FEEDBACK

As a partial answer to this requirement, engineers and engineering psychologists have adapted the ubiquitous feedback model to describe the human operator as an element in the continuous control of complex aerodynamic, hydrodynamic, or similar environmental processes [14]. Figure 1 is a typical representation of the feedback or servo model. The process is the

[1]The process $R_1 \rightarrow S_2$ is not necessarily mediated by physical events outside the organism but may be mediated by biological events within, as in kinesthesis.

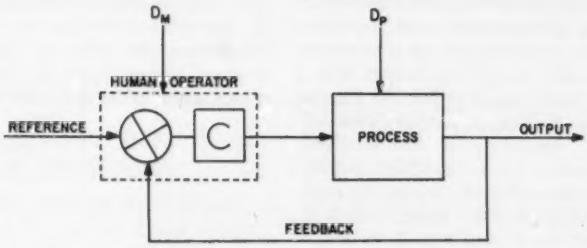

Fig 1. The Feedback model

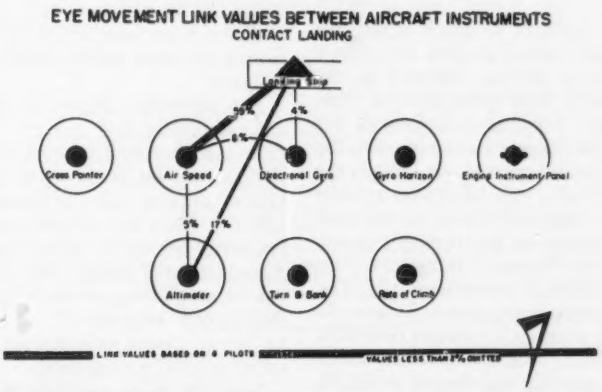

Fig 2. Intermittent observation of multiple displays during continuous control task. (From Milton, J. L., et al, AF Tech. Rpt. No. 6018).

independently energized function which is to be controlled. The operator is represented by the electrical symbol for a summing junction and by a control mechanism. Actually the box representing the human operator should contain a complex of comparators, differentiators, integrators and various non-linearities. For the sake of simplicity we have represented only those functions which will enter into our discussion. The arrow leading away from the operator indicates his response, or action on the process. The two arrows D_m and D_p represent those disturbances to the man and the process respectively which cause the process output to deviate from the ordered input or reference. The reference, represented by a second arrow to the operator, is, as Fitts puts it, "the desired state of the system that the individual sets himself to achieve" [6]. This may be a contemporaneous stimulus or it may be the residual of previous experience. The experience can take many forms, prior instructions and training being two. The third arrow is the input from stimulus objects that display the output feedback signal. Feedback may arrive via any modality, although the visual sense is predominant.

As an element in a feedback system the human operator (1) receives the output feedback and the ordered input or reference, (2) detects any difference between these two values, and (3) on the basis of the difference initiates a control response which will bring the output of the system into the desired relationship with the ordered input. If necessary he may recode the feedback signal to make it comparable with the reference. The operator's observation of reference and feedback, and his detection of a difference between them, is usually inferred from his response.

MONITORING

The application of the feedback model to continuous control has been quite fruitful, leading for example to the Taylor and Birmingham principles of quickening and unburdening [3]. Continuous control or tracking tasks, however,

are only a small part of the human control function in complex man-machine systems. More often the human operator acts as a monitor. That is, he compares the process output with a reference input as in tracking, but his control response, instead of being apparently continuous, is markedly discontinuous and relatively infrequent. Even the pilot, whose difficult tracking task has been so assiduously studied by engineers and psychologists, has a large burden of monitoring operations to perform. A record of the eye-movements made by a pilot in landing his aircraft clearly demonstrates this fact in Figure 2 [17].

Although the servo or feedback model has been primarily used in the analysis of continuous control there is nothing inherent in the concept to prevent it from being used, as Howland has suggested [10], as a framework for the analysis of the more common monitoring behavior. In fact, under microscopic analysis the human in a continuous control system actually does behave like a monitor. Except in the most exceptional circumstances his response is not continuous but discontinuous, being made up of a sequence of ballistic movements [8]. The human can be approximately linear in a tracking task when the stimulus is a simple sinusoidal motion, not exceeding 3 cps, with which he has had considerable practice and toward which he has developed strong expectancies [6]. In general, however, he acts like an intermittent or sampling servo, and other elements in the system smooth out his saccadic responses. Since it is characteristic of biological systems to function discontinuously it might be more useful to consider so-called continuous control to be a special limit case of monitoring in which the response discontinuities are apparent only to microscopic analysis.

The feedback model subsumes the stimulus-organism-response model, and many reaction time and psychophysical data, obtained in psychological experiments based on the S-R and the S-O-R paradigms, fit neatly into the extended feedback analysis of system behavior. If the monitor is unaware of the unique effect of his action on the output of the system (a situation that may arise when the operator is but one element in a long biomechanical chain, such as a radar early warning system, and is so remote from the effect of his response on the process that he cannot see any relationship between his response and the process output) then the straight transmission, or S-O-R model, is perhaps sufficient. Frequently in monitoring, however, lags are short and there is only one operator in the system so that he has little difficulty identifying the effect of his response on the process. Under these conditions the feedback model seems more desirable than the open loop.

THE VARIABLES OF MONITORING BEHAVIOR

The feedback diagram in Figure 1 shows the order in which one part of the system is related to another. For a complete description of the relationship it is necessary to specify the variables in the dynamic behavior of the system. These are listed below and have to do mostly with the three functions of the operator: reception of the input and feedback, comparison, and response.

A fundamental dimension of both observing and responding is frequency. Some monitoring tasks are characterized by continuous observation of the feedback signal by the operator. Others require only infrequent sampling on either a fixed or variable schedule. Response frequency has already been observed to run the gamut from the intermittent response characteristic of monitoring, through the microscopically intermittent response of "continuous control", to the rare case of continuous response achieved under special circumstances.

Logically there are four possible combinations of intermittent or continuous observation, and intermittent or approximately continuous response. In reality the combinations of continuous observation and intermittent response, and intermittent observation and intermittent response, are common. Apparently continuous response to a continuously observed and variable signal is well-known as tracking. It is difficult to think, however, of an example of the fourth case, intermittent observation and continuous control, unless we include an apparently continuous response based on the comparison of a stored feedback signal with a reference. This might be said to be the case for example when the pilot continues to change course while he shifts his attention from the landing strip to the air speed indicator when landing.

Error is defined as a difference at the summing junction between the reference input and the output feedback. It results from a disturbance to the process, or to the operator, or from a change in the reference. It may be continuous; it may be a pulse-like deviation from, and return to, a steady state; or it may be a change, either gradual or abrupt, from one steady state to another. All of these errors occur in monitor-

		1. ADAMS	2. BAKAN	3. BROADBENT	4. DEESE & ORMOND	5. HOLLAND	6. HOWLAND	7. MACKWORTH	8. JERISON & WING	9. JERISON & WALLIS	10. JERISON & WALLIS
LOOP	1. KIND	OPEN	OPEN	CLOSED	OPEN	CLOSED	OPEN	OPEN	OPEN	OPEN	OPEN
	2. NUMBER	ONE	ONE	TWENTY	ONE	ONE	FOUR	ONE	THREE	ONE / THREE	ONE
REFERENCE	3. TYPE	UNIFORM BACKGROUND ILLUMINATION .23 APPARENT FT C.	STD. BRIGHTNESS 1.1 FT 'L'	POINTERS 1 DIV BELOW DANGER LEVEL	UNIFORM SCOPE BRIGHTNESS, -50 V.	NULL POSITION OF POINTER	MEAN VALUES OF FLUCTUATING POINTERS	SINGLE POINTER JUMPS	SINGLE POINTER JUMPS, .03 SEC. DURATION	SINGLE POINTER JUMPS, .03 SEC. DURATION	SINGLE POINTER JUMPS, .03 SEC. DURATION
	4. DURATION	CONTINUOUSLY AVAILABLE FOR COMPARISON	REPLACED BY SIGNALS, MUST BE STORED BY S	REPLACED BY SIGNALS, MUST BE STORED BY S	CONTINUOUSLY AVAILABLE FOR COMPARISON	REPLACED BY SIGNALS, MUST BE STORED BY S	REPLACED BY SIGNALS, MUST BE STORED BY S	→	→	→	→
ERROR SIGNAL	5. TYPE	PULSE	PULSE	STEADY STATE	PULSE	STEADY STATE	STEADY STATE	PULSE	PULSE	PULSE	
	6. INTENSITY	2nd SPOT OF LIGHT / CONSTANT .016 & .019 APPARENT FT CANDLES	LIGHTED AREA - 15° ARC	POINTER ABOVE DANGER LEVEL / CONSTANT 2 1/2 DIVISIONS OF DIAL	POINTER / CONSTANT "WEAK SIGNALS"	POINTER DEFLECTION / CONSTANT	DIFF. MEAN VALUE OF POINTER RDNGS / CONSTANT	POINTER / DOUBLE JUMP / CONSTANT	POINTER / DOUBLE JUMP / CONSTANT	POINTER / DOUBLE JUMP / CONSTANT	POINTER / DOUBLE JUMP / CONSTANT
	7. FREQUENCY	VARIED n - 1 PER MIN	VARIED n - 6 PER 15 MIN	VARIED n - 5 PER 30 MIN	VARIED 10, 20, 30, & 40 PER HOUR	VARIED WITH SCHEDULE USED	VARIED 14 PER 4 HOURS	VARIED n - 12 PER 20 MIN	VARIED WITH CLOCK 60 - 36.7 / PER MIN - 25.1 - 24.0	VARIED n - 13 PER 30 2/3 MIN / n - 39 PER 25 MIN	VARIED n - 13 PER 26 2/3 MIN
	8. DURATION	1 & 2 SEC	2/3 SEC	VARIED WITH S's RESPONSE	CONSTANT SINGLE SWEEP OF PPI CRT	VARIED WITH S's RESPONSE	VARIED n = 11.43 MIN	CONSTANT / POINTER DOUBLE JUMP	.06 SEC	.06 SEC	.06 SEC
	9. RISE TIME	FAST	FAST	FAST	FAST	FAST	FAST	FAST	FAST	FAST	FAST
	10. NOISE	* *	* *	* *	3-V Rms	* *	* *	* *	* *	* *	* *
	11. SIGNAL/NOISE	* *	VARIED	* *	* *	* *	* *	* *	* *	* *	* *
OBSERVATION FREQUENCY	12. REFERENCE	CONTINUOUS	2/3 OF EVERY SEC MINUS 6 SIG PER 15 MINUTES	S's CONTINUOUSLY SCANNED DISPLAYS	CONTINUOUS	VARIED WITH SCHEDULE	CONTINUOUS	CONTINUOUS	S's CONTINUOUSLY MONITORED DISPLAYS	CONTINUOUS / S's SCANNED DISPLAYS	CONTINUOUS
	13. FEED BACK	UNKNOWN + →	+ →	+	+ →	VARIED WITH SCHEDULE	UNKNOWN → +	+	+	+ →	+ →
	14. OPERATOR SENSITIVITY	DECREASED WITH TIME	DECREASED WITH TIME	VARIED WITH S's & TIME	INCREASE WITH RATE OF SIGNAL PRESENTATION	* *	CONSTANT	DECREASED WITH TIME	DECREASED WITH TIME & NOISE	DECREASED WITH TIME	DECREASED WITH TIME
	15. RESPONSE FREQUENCY	VARIED WITH TIME, SIGNAL INTENSITY AND DURATION	VARIED WITH TIME AND SIGNAL INTENSITY	VARIED WITH S's & TIME	VARIED WITH SIGNAL RATE & SEARCH PERIOD	VARIED WITH SCHEDULE	VARIED WITH EXP. GROUPS	VARIED WITH TIME	VARIED WITH TIME & NOISE	VARIED WITH TIME / CONSTANT	VARIED WITH TIME

* * NOT SPECIFIED.
* SIMULATED "FEEDBACK" SIGNAL ORIGINATES IN PROCESS NOT CONTROLLED BY S.
\+ UNKNOWN EXCEPT AS INFERRED FROM RESPONSE.

Fig 3. Summary of ten experiments on monitoring.

ing situations. For example, the rise and fall of temperature about some norm is a continuous error signal. The sudden appearance and disappearance of a sonar "ping" is a pulse-type error. The abrupt change in water circulation due to an obstruction is an example of a change in the process from one steady state to another. In general, all of these errors can be classified by their frequency of occurrence, amplitude, duration, and rate of onset or rise time.

The sensitivity of the summing junction is defined as its difference threshold. When the error exceeds the difference limen (DL) of a summing junction it leads either directly or indirectly to a control response which attempts to reduce the error to zero. When the human operator functions as a summing junction his DL is determined by experience (including instruction), the DL of the sensing modality, and the display configuration.

Time constants include the latencies of feedback and control actuation and are the most thoroughly investigated variables in the psychological study of continuous control.

A characteristic of the control response which is difficult to classify is reversibility. It is an important characteristic, however, since the exercise of irreversible control may be a responsibility reserved for the human monitor, a part of his decision-making function. A reversible control response modifies the process, but not beyond a point from which it cannot be recovered by a similar, generally opposite, response. An irreversible response on the other hand either stops the process by cutting off the source of energy, or otherwise alters the process so that it must go through some other phase, such as start-up or maintenance, to bring it back to the same operating condition. This has lately been identified in decision making as an irrevocable decision. A dramatic and topical example occurs in missile control. The feedback from the aerodynamic process is information about the missile trajectory. If the actual trajectory deviates from the ordered trajectory to a degree considered dangerous by the range safety officer, the dynamic process is irreversibly altered by exploding the missile from the ground.

VIGILANCE AND MONITORING EXPERIMENTS

A number of experiments have been conducted on what are called monitoring, vigilance, or watch-keeping tasks. These laboratory tasks are designed to be analogous to real-life behavioral situations. The operator compares the output of the process with a reference implicit or explicit in his instructions, and then responds, when he detects a discrepancy between the two inputs greater than his threshold for action, in a manner to affect the process output. In eight out of ten typical laboratory investigations the response did not, however, affect the process since the aim in these experiments was to study detection as a function of time, and the probability of signal incidence was held constant throughout each trial, shown in Figure 3. In two cases, Broadbent and Holland, the subject's control response did, in fact, reset the error to zero, giving him a short-lag control over a very simple process in a closed loop. Whether the loop is open or closed, this research approach seems to be the closest laboratory approximation to this kind of control requirement.

Man considered as a monitor poses a complication for straightforward servo analysis. The feedback model shown in Figure 1 represents only a single loop. There is only one process, one feedback signal, one reference input, and one control. In reality a single operator may be required to monitor simultaneously several processes, or aspects of the same process, and may have separate references and separate controls for each. At this point servo theory becomes somewhat meager for the description of human behavior. All that can be said is that, in those cases where the operator clearly attends to each feedback display in sequence, he is time-shared or multiplexed between the two or more loops. Four of the ten experiments in the survey were such multi-loop experiments. However, in none of these was a record made of the spontaneous distribution of the operator's observing responses among the several feed-back displays. Holland [9] recorded the observing responses but his subjects monitored only one display.

Adams [1], using a single, open-loop design, investigated the decrement in performance through time when there was an occasional pulse-like deviation of the process output from the input reference. The reference was a uniform noise background on a simulated radar scope and the error signal appeared as a spot of light. The instructions to the subject defined the appropriate response. Two signal durations and two signal amplitudes were used. Signal frequency varied but averaged one per minute. Adams found that detection decreased with time and was directly related to error signal duration and amplitude.

Bakan [2] also use da single, open-loop design to examine performance decrement through time. He made repeated threshold measurements of the sensitivity of the monitor to abrupt increases in the process output, that is background illumination, from the reference input, low-level background illumination. Error signal frequency varied around a mean value of 6 per 15 min. Since threshold measurements were the goal, signal amplitude was varied while duration was held constant. Bakan found performance decrement.

Broadbent [4] used a closed, multiple-loop design to study the characteristics of watch-keeping. The reference input specified that the pointers on twenty dials be below a danger level. The dials were mounted on panels positioned to form three sides of a square around the subject. Error signals were deviations of pointers above the danger levels. Frequency of signals varied about a mean value of 5 per 30 min. and signal intensity was constant. Rise time was very fast. Since subjects were required to rest the pointer to zero when an error was detected, signal duration depended on the subject's response time. Broadbent found that detection varied with practice, subjects, and dial position.

Deese and Ormond [5] used a single, open-loop design in their five experiments on visual search. The reference input was normal background illumination with a 3-v rms noise source present at all times on a simulated radar scope. They varied rate of target (signal) presentation, inter-target time interval, spatial distribution of targets, and length of search time. Error signals were weak pips of constant intensity and duration which were presented in a variable manner at mean rates of 10, 20, 30 or 40 per hour. Probability of detection was found to vary directly with rate of signal presentation. Search time had large effects on the form of the detection curve but not on average percent of targets identified.

Holland [9] used a single, closed-loop design in a study of the pattern established by the operator in sampling the feed-back. An occasional pointer deflection indicated the deviation of process output from a zero reference. The deviation or signal was a steady state error which

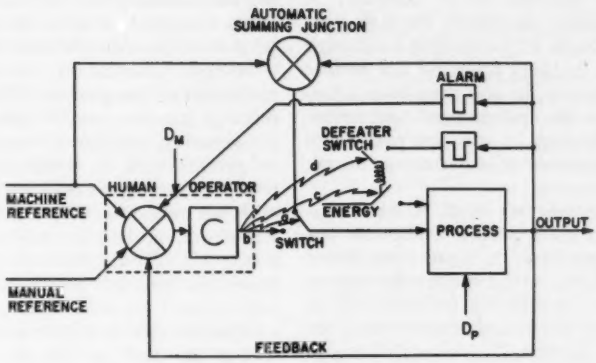

Fig 4. Monitors in series and parallel.

was curtailed when the subject reset the pointer. Signal frequency followed fixed and variable ratio and interval schedules. Signal amplitude was constant, and duration, of course, was determined by the occurrence of the subject's response. Holland measures the operator's observations of the feedback display by placing the subjects in a dark room and requiring them to depress a key in order to illuminate the display for a short fixed interval. Successive key depressions were required for successive observations. The observation and response frequencies were found to vary with the schedule; the data were similar to those obtained from infra-human subjects in other experiments with a similar design.

Howland [10] had his subjects share their attention among four open loops and studied their performance change through time. Each feedback display had a separate associated control although the subject's response did not affect the process. An error signal appeared as an occasional steady-state deflection of a pointer from its previous position which, as soon as determined, had become the reference. Noise degraded the feedback signal; the pointer varied randomly around a mean steady-state value with an average frequency of 2.2 changes per min. per display. Signal frequency was irregular, 14 occurring randomly in a four hour period. Signal intensity was constant and the duration averaged 11.43 min. Howland did not find a decrement in performance during his four-hour observation period.

In a series of experiments Mackworth [15] devised and used the clock test which bears his name. In these studies a single, open loop was involved and the general aim was to determine factors affecting performance decrement through time. In a typical experiment the reference was the regular single jump of a pointer against a blank-faced dial and the signals were double jumps which occurred irregularly with a mean value of 12 during the first 20 min. of each half-hour. Mackworth demonstrated not only a consistent decrement in performance after 30 min. but also showed that environmental stress, knowledge of results, and drugs affect vigilance performance.

Jerison and Wing [13] used a multiple, open-loop design in their study of the effect of auditory noise and fatigue on performance. Three Mackworth-type clocks, each with its own control, were monitored for occasional signals, double jumps by the pointers when the reference was regularly occurring single jumps. Error signal frequency varied around a mean value of 39 per 25 min. for the three displays. Signal amplitude and duration were constant. No difference was found in performance between the noise (114 db) and quiet (83 db) groups for the first 1½ hours of work, but beyond this time the noise group's performance declined significantly.

Jerison and Wallis [11,12] used both one and three open loops in their studies of performance decrement as a function of time. In their multi-loop study three Mackworth-type clocks, each with its associated control, were placed side by side. In the single-loop experiment one clock was used. The error signal in both multi- and single-loop experiments was a double jump by the clock pointer in contrast to the single-jump reference input. Signal frequency varied randomly around mean values of 13 per 26-2/3 min. in the single loop experiment and 39 per 25 min. in the multi-loop situation. Signal

amplitude and duration were constant. A marked performance decrement through time occurred in the single loop experiment although an added 79 db auditory noise did not further degrade performance. In the three-loop situation there was no pronounced decrement through time although it was not possible to rule out the occurrence of a decrement during the first three minutes.

It should be noted that in all of the multi-loop experiments the appropriate response was the same for each loop. A more complicated and realistic problem would require the appropriate response to be different for each loop or perhaps a function of the interaction among the several feedback displays.

MONITORS IN SERIES AND IN PARALLEL

Frequently monitors are combined in series, in parallel, or in series parallel. In these more complex cases all the monitors may be human or there may be various combinations of automatic and human control. Since this arrangement is so common it seems practical to pay some systematic attention to it. Figure 4 is a more general servo model which takes into account control systems in which there is human control, automatic control or a combination of both.[2] To cover a situation in which there is a combination of human and automatic control there are two principal feedback loops, one to the automatic monitors and one to the human operator. There are also separate automatic and human reference inputs.

As in the simpler model in Figure 1, the arrows (*a, b, c, d*) leading away from the operator represent alternative responses and two of the arrows leading to the operator represent the output feedback and the reference input. The operator himself can select either the automatic or the manual mode of control (*a*). When in the manual mode we have the simple feedback system described in Figure 1, and all of the variables discussed with respect to the simple system are applicable. The operator may be either a tracker or a monitor. His control response is shown by arrow (*b*). One of his alternatives as a monitor is to open the switch (*c*) and stop the process by cutting off the supply of energy to the process.

The automatic side of the feedback control system is comprised of three loops in parallel: an automatic continuous control circuit containing the summing junction, and alarm and shutdown circuits. One or all of these circuits may be present in a real-life situation.

Several combinations of human and automatic control are possible. When there is automatic continuous control through the mechanical summing junction the operator is generally in parallel with it, continuously or intermittently comparing his own feedback information with his own reference, which may include his knowledge of the reference input to the automatic side of the system. If the deviation between his feedback information and his reference exceeds his limit, then he has two control alternatives. The first is to intervene, that is, to change the mode of operation to manual (*a*) and take over continuous control himself (*b*), or he can open the shutdown switch (*c*).

If there is an automatic alarm circuit in the system there are again two parallel feedback paths. One is the usual manual feedback, the other is via the alarm. The path that contains the alarm is actually comprised of two monitors in series: the alarm which compares the feedback with its preset threshold value, and the operator who compares the output of the alarm with his own reference, generally "no alarm is normal," and exerts some more appropriate control on the process in the event of a discrepancy. This series arrangement is the same relationship classified by Howland as a "Level II" monitor [10][3]

If there are both alarm and shutdown circuits in the control system, the threshold of the alarm may lower that of the shutdown circuit. If the limit of both are exceeded the operator may still override the shutdown circuit and keep the process in operation by opening the defeater switch (*d*).

More elaborate networks can be built up to represent real-life situations but the combinations shown here seem to contain the basic elements.

SUMMARY

The feedback principle seems to be a useful paradigm for the analysis of human behavior since, unlike the open transmission concept, it

[2]The authors are indebted to E. F. Hendry for several contributions to this model.

[3]Howland describes three "levels" of monitoring "where levels refer to the functions and responsibilities of the monitor." His Level III monitor combines the three functions of observation of feedback and reference, comparison, and response, and is compatible with the present definition of a simple monitor. A Level I monitor is a transducer in the feedback path which senses the output signal and relays it, with or without recording, to the summing junction for comparison with the reference and for action.

pulls together in one framework the environmental process and the human operator's interaction with it. While this advantage has been successfully exploited in so-called continuous control situations, leading to such principles as quickening and unburdening, the concept has only been recently mentioned as appropriate to the more common forms of intermittent behavior called monitoring. A simple feedback model is discussed and the associated variables identified. These include frequency of observation and response, sensitivity, time constants in feedback and control, and reversibility of control.

Ten monitoring or vigilance experiments are analyzed in terms of the model. In most cases the effect of the response on the process was eliminated or occurred without lag in order to study the effect of time on performance.

The model is extended to show monitors, both human and automatic, combined in series and in parallel. In conclusion it is suggested that basic experiments on monitoring be derived from the feedback paradigm.

REFERENCES

1. ADAMS, J. A., Vigilance in the detection of low-intensity visual stimuli. *J. exp. Psychol.*, 1956, *52*, 204-208.

2. BAKAN, P., Discrimination decrement as a function of time in a prolonged vigil. *J. exp. Psychol.*, 1955, *50*, 387-390.

3. BIRMINGHAM, H. P., and TAYLOR, F. V., A human engineering approach to the design of man-operated continuous control systems, NRL Report 4333, Naval Research Laboratory, Washington 25, D.C. 1954.

4. BROADBENT, D. E., The twenty dials test under quiet conditions. Medical Research Council, A.P.U., Rpt. 130/50.

5. DEESE, J. and ORMOND, ELIZABETH, Studies of detectability during continuous visual search. WADC Technical Report 53-8, July 1953.

6. FITTS, P. M., Engineering psychology and equipment design, Chap. 35 in S. S. Stevens, *Handbook of Experimental Psychology*, John Wiley and Sons, New York, N.Y., 1951.

7. *Handbook of human engineering data*, 2nd edition, rev., Tufts College Institute for Applied Experimental Psychology, Medford, Mass., 1952.

8. HICK, W. E., The discontinuous functioning of the human operator, *Quart. J. Exp. Psychol.*, Vol. 1 (1948), pp 36-51.

9. HOLLAND, J. G., Technique for behavioral analysis of human observing. *Science*, 1957, *125*, 348-350.

10. HOWLAND, D., The human as a monitor in a man-machine system. *News in Engineering*, Ohio State University, July 1956, 23-29.

11. JERISON, H. J., and WALLIS, R., Experiments on vigilance: One clock and three clock monitoring. WADC Technical Report 57-206, May 1957.

12. JERISON, H. J., and WALLIS, R., Experiments on vigilance: Performance on a simple vigilance task in noise and in quiet. WADC Technical Report 57-318, June 1957.

13. JERISON, H. J., and WING, SHELLY, Effects of noise and fatigue on a complex vigilance task. WADC Technical Report 57-14, January 1957.

14. LOCKARD, R. B., Bibliography of human engineering reports on tracking, NAVORD Report 5272, US Naval Ordnance Test Station, China Lake, Calif., 15 April 1956.

15. MACKWORTH, N. H., Researches on the measurement of human performance. MRC Special Report No. 268, London: H. M. Stationery Office, 1956.

16. MILLER, N. E., and DOLLARD, J., *Social Learning and Imitation*, Yale University Press, New Haven, 1941.

17. MILTON, J. L., JONES, R. E., and FITTS, P. M., Eye fixations of aircraft pilots: V. Frequency, duration, and sequences of fixations when flying selected maneuvers during instrument and visual flight conditions. Air Force Technical Report No. 6018, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio, August 1950.

18. WOODSON, W. E., *Human engineering guide for equipment designers*, Berkeley, Calif., Univ. of California Press, 1954.

Forces That May Be Exerted By Man In The Operation of Aircraft Door Handles

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Six handle configurations were tested by 8 male subjects on a test arrangement simulating an aircraft door. The torques exerted by the subjects were measured in angular increments of 45°. Over 1200 static and dynamic measurements were made. A limited check study on 10 females, totaling 120 measurements, was also made. The shape, length, direction of movement, arc of motion, effects of one-handed operation, maximum torques and differences between sexes are discussed.

The CAA Medical Research Laboratory conducted a series of evaluations of the ability of men and women to operate a variety of aircraft main cabin door handles. This study was performed at the request of the Committee for Aircraft Cabin Safety and Standardization (S-9) of the Society of Automotive Engineers. Three types of handles and two sizes of each type were evaluated by both static and dynamic tests.

In the static tests, over twelve hundred torque measurements taken at 45° intervals in both clockwise and counter-clockwise directions were made, using light male subjects. The anthropometric measurements of the subjects are shown in Table I. For comparison, one hundred and twenty static measurements were obtained using ten female subjects. Their measurements are shown in Table II. Maximum static forces were recorded from a Dillon dynamometer during a three- to five-second muscular contraction.

In the dynamic tests, the maximum strength available for rotation of the handles under a constant load through a 180° arc was measured in the clockwise direction. The handle loading was gradually increased until the subject was unable to complete a 180° rotation in one continuous effort. Forces considerably higher than those measured during a continuous effort were found, however, by allowing the subject to hesitate and reposition his hands and body more advantageously and make a renewed effort to rotate the handle through the remainder of the 180° arc. Over 85 dynamic measurements were obtained for "continuous" and "discontinuous" rotation on those subjects previously used for the static measurements.

The following handle types were used:

1. An L-shaped handle, i.e. a main shaft with a bar perpendicular to it.
2. A double L-shaped handle, i.e. having two bars, each perpendicular to the main shaft, and to each other.
3. A T-shaped handle, i.e. two bars perpendicular to the main shaft, but extending on opposite sides of the shaft to form a a straight line.

These are shown in Fig. 1. The location of the handles with respect to the floor and interferences which simulate an aircraft situation is shown in Fig. 2.

RESULTS

The results of our studies are summarized below.

Shape

From the standpoint of torque that could be applied, the T-handle proved superior. The double L was next, and the single L was the least effective of the three types. The mean of the maximum values for the eleven-inch T-handle exceeded the eleven-inch double L handle by 20 per cent and the eleven-inch single L handle by 37 per cent. The five-inch T-handle exceeded the five-inch double handle by 24 per cent and the five-inch single L by 40 per cent.

Maximum forces that could be exerted at different angles of rotation were more consistent with the T-handles than with the other two types.

TABLE I

Anthropometric Measurements of Male Subjects
(All values in inches unless otherwise indicated).

Anthropometric Measurements	SUBJECT J.S.	P.R.	J.B.	O.W.	P.G.	C.W.	P.S.	J.G.
1. Age (yrs.)	42	29	29	35	29	31	35	37
2. Weight (lbs.)	159	183	165	172	196	122	261	152
3. Stature	68	68.5	71	69.5	73.5	67.5	70.5	65.5
4. Anterior arm reach	34	34	37	33.5	35.5	33.5	35.5	32
5. Arm length	32	31.5	34	30.5	33.5	30.5	31	29
6. Hand height	24.5	26	25.5	26.5	28.5	27	28.5	26
7. Crotch height	29.5	31.5	33.5	32.5	35	32.5	32	30
8. Upper arm circumference	12	13.5	12.5	12	12.5	9.5	15.5	12
9. Chest circumference	35.5	41	37.5	39	41.5	33	49.5	37
10. Abdominal girth	30.5	34	30.5	34.5	37.5	26	47.5	32.5
11. Chest width (bi-deltoid)	16	17	17	16.5	17	15	16.5	15.5
12. Chest depth	9	9	7.5	9	9.5	6.5	10.5	8.5
13. Buttocks width (bi-trochanteric)	13	13.5	13	13.5	14	12.5	15.5	13
14. Abdominal depth	9.5	9.5	8	8.5	9.5	6.5	14	9
15. Sitting height	34.5	35	36	37	36.5	35	38	34
16. Trunk height	22.5	22.5	23.5	23	24.5	22.5	26.5	22
17. Buttocks knee	24	24.5	25	22.5	26	22.5	23.5	23
18. Patella height	21.5	21.5	22.5	21	23	21	21.5	20
19. Thigh circumference	19	20.5	20.5	19.5	19.5	16	22.5	19

TABLE II

Anthropometric Measurements of Female Subjects

Anthropometric Measurements	SUBJECT T.McF.	J.J.S.	J.S.	S.C.	C.C.	C.M.	M.C.	A.W.	B.B.	A.G.
1. Age	37	34	30	30	28	29	27	30	28	36
2. Weight (lbs.)	123.5	118	131	146.5	123	122	131	117	110	140
3. Stature (in.)	65	64	66.5	69	62.75	67.5	69.75	66	64	63.5
4. Anterior arm Reach (in.)	32	32.5	29.5	32	30	32.5	33.5	34	31.5	31
5. Arm length (in.)	28	28	28	30	28.5	29.5	30.5	31	29	28.5
6. Hand height (in.)	26.5	24	27.5	27	24	26.5	26	25	24	24

Direction

Clockwise forces that the subject could exert on a given handle in a given position did not show statistically significant differences from those that could be exerted in a counter-clockwise direction on the same handle when the subject was in a position equivalent to the mirror image of the clockwise position.

Length

The torque that could be exerted on the eleven-inch handles was about 2½ times that which could be exerted on the five-inch handles. This can be explained by the fact that the hand cannot apply a force closer than one inch from the end of the handle. Therefore, the effective radii of the handles were 10 inches and 4 inches. Forces exerted by the subjects were derived from torque measurements in accordance with the formula

$$\text{Force} = \frac{\text{Torque}}{\text{Length of handle from center} - 1}$$

where Torque is expressed in inch pounds
Length is expressed in inches
Force is expressed in pounds.

Statistical measures indicate that the derived values of force were not significant when data from the eleven-inch and five-inch handles were compared. Coefficients of correlation exceeded 0.8 in all instances.

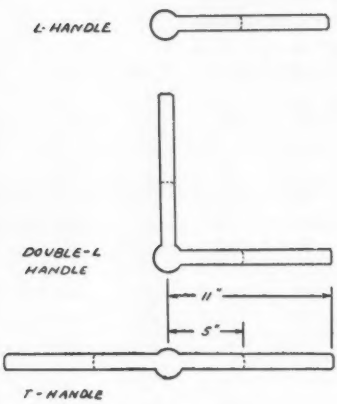

Fig 1. Handle on figurations.

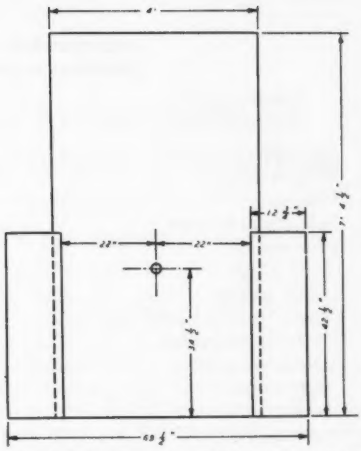

Fig 2. Handle locations with respect to floor and interferences.

TABLE III

Forces on Single L-Handles—Men

IIIA — One Hand

Clockwise Angle Position	Counter-Clockwise Angle Position	Mean Force (lbs)	Standard Deviation (lbs)
0°	180°	150	51.7
45°	135°	110	34.8
90°	90°	86	23.8
135°	45°	93	22.1
180°	0°	108	20.3
225°	315°	80	17.5
270°	270°	90	23.2
315°	225°	132	35.0

IIIB — Two Hands

0°	180°	156	60.0
45°	135°	126	46.7
90°	90°	128	38.6
135°	45°	151	44.0
180°	0°	141	43.1
225°	315°	122	35.9
270°	270°	138	35.0
315°	225°	178	50.6

The total length of complex handles is not a good index of the relative force effectiveness of the handle. For example, the mean of the maximum forces obtained with the eleven-inch double L handle and eleven-inch T-handle, each with a total length of 22 inches, were only 20 per cent and 37 per cent, respectively, greater than the 11-inch L-handle.

One-Handed Operation

One-handed operation of singe L-handles gave an average maximum static force which was close to 75 per cent of the two-handed operation.

Maximum Torques

The maximum torques that were exerted on the six handle configurations by any individual without regard to direction of rotation were as follows:

	Men	Women
11 in. T	4140 in. lbs.	2400 in. lbs.
11 in. L-L	3240 in. lbs.	
11 in. L	2800 in. lbs.	1700 in. lbs.
5 in. T	1350 in. lbs.	
5 in. L-L	1220 in. lbs.	
5 in. L	1260 in. lbs.	

Arc of Motion

In general, the best position for applying force to a handle is one in which a subject can use his legs and lift. The next best is in pushing down and using body weight. The least effective method is the employment of an over or under motion. The under motion is slightly superior.

Forces which were exerted for "continuous" and "discontinuous" dynamic rotation from 0° to 180° with the double L handle and the T-handle were comparable to the mean of the static values for these positions. (0° is horizontal to the left of center, 90° is above center, 180° to the right of center.) "Continuous" and "discontinuous" values for the single L handle were considerably higher in the area of the 90° position when compared to the mean static measurements. With a constant load, it is possible to start accelerating at 0° and receive inertial assistance over the 90° "hump", the region of greatest disadvantage in the application of force.

Subjects

Forces vary between individuals not only because of muscular strength, but also because of

TABLE IV

Forces on Double L-Handles—Men

Clockwise Angle Position	Counter-Clockwise Angle Position	Mean Force (lbs)	Standard Deviation (lbs)
0°	90°	203	63.7
45°	45°	156	56.2
90°	0°	185	47.9
135°	315°	166	40.5
180°	270°	155	41.0
225°	225°	190	51.3
270°	180°	186	52.2
315°	135°	201	55.0

TABLE V

Forces on T-Handles—Men

Clockwise Angle Position	Counter-Clockwise Angle Position	Mean Force (lbs)	Standard Deviation (lbs)
0°	180°	234	59.0
45°	135°	224	57.7
90°	90°	225	51.5
135°	45°	239	64.1

Note that 180°, 225°, 270° and 315° are the same as 0°, 45°, 90°, and 135°

differences in leg and arm length when lifting a handle at a fixed distance from the floor. Check experiments indicated that women subjects were capable of applying an average maximum force equal to approximately 60 per cent of force exerted by the male subjects.

Summary data for the forces exerted by men are shown in Tables III, IV and V. Clockwise and counter clockwise results are combined. The results from the five inch and the eleven-inch handles are combined by converting the torque measurements to force. Tables VI and VII give the complete data of the torques exerted by the women subjects.

A graphic presentation of the forces that were exerted by the male subjects is given in Figure 3 through 6, where the mean of the maximum forces exerted by the subjects is shown together with the 5th percentile and 95th percentile values. These figures show the benefits of two-handed operation of single L handles over one-handed operation. They also show the increase in force and uniformity in the application of force that was achieved in the T-handle.

Note: Original unpublished data on this study will be filed with American Documentation Institute and may be obtained on microfilm.

TABLE VI

Individual Static Measurements of the Maximum Torque Applied by Women Subjects to 11 in. Single L-Handles, Clockwise.

Torque in Inch Pounds at Various Angles

	0°	45°	90°	135°	180°	225°	270°	315°
T. Mc.	1620	1530	405	765	990	855	697	1372
J. J. S.	1053	1710	607	765	990	810	810	1260
J. S.	720	607	900	630	945	1035	630	1282
S. C.	765	652	720	720	900	832	652	1575
C. C.	495	495	450	495	787	540	382	630
C. M.	450	585	675	585	810	450	540	945
M. C.	855	810	630	855	1080	810	1125	1328
A. W.	743	675	720	765	990	945	1395	1687
B. B.	810	472	810	315	945	810	945	1260
A. G.	1125	900	900	1035	1170	900	900	1215
Average	863.6	843.6	681.7	693.0	960.7	798.7	807.6	1255.4

TABLE VII

Individual Static Measurements of the Maximum Load Applied by Women Subjects, 11 in. T-Handles, Clockwise.

Torque in Inch Pounds at Various Angles

	0°	45°	90°	135°
T. Mc.	1462	1935	1305	2385
J. J. S.	1350	1462	945	1912
J. S.	1125	1215	1080	1507
S. C.	900	1327	630	1620
C. C.	967	945	810	990
C. M.	1080	1103	495	981
M. C.	1530	1800	1462	1575
A. W.	990	1665	1890	1462
B. B.	945	1530	990	1417
A. G.	1305	1530	1125	1665
Average	1165.4	1451.2	1073.2	1551.4

180°, 225°, 270° and 315° are the same as 0°, 45°, 90° and 135°.

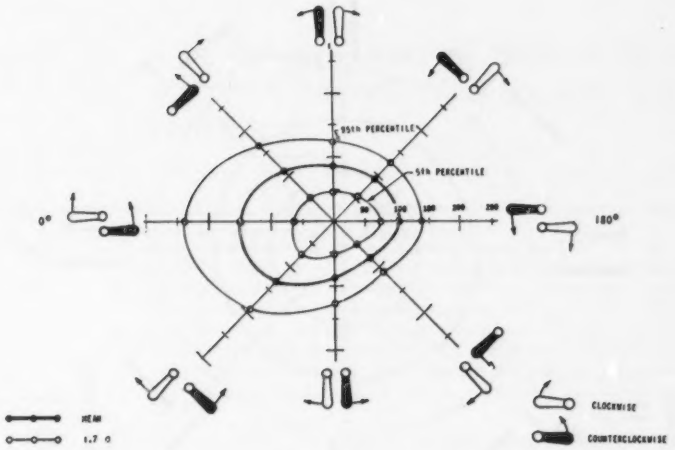

Fig 3. Absolute forces for one hand operation of single L handles as reduced to the apparent point of application. Magnitude of force is in pounds at each 45° of rotation is illustrated by the radial distance from the center. Male subjects.

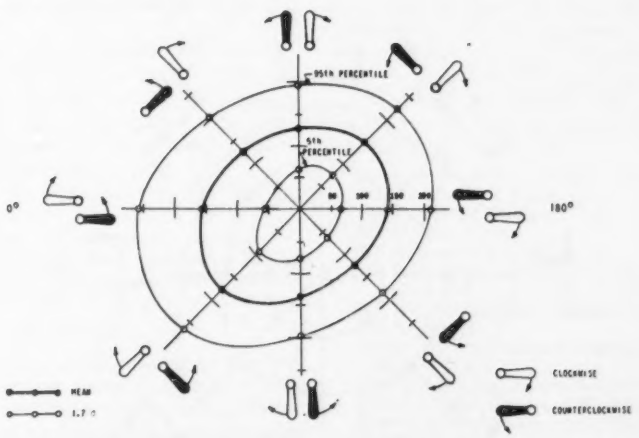

Fig 4. Absolute forces for two hand operation of single L handles as reduced to the apparent point of application. Magnitude of force in inch pounds at each 45° of rotation is illustrated by the radial distance from the center. Male subjects.

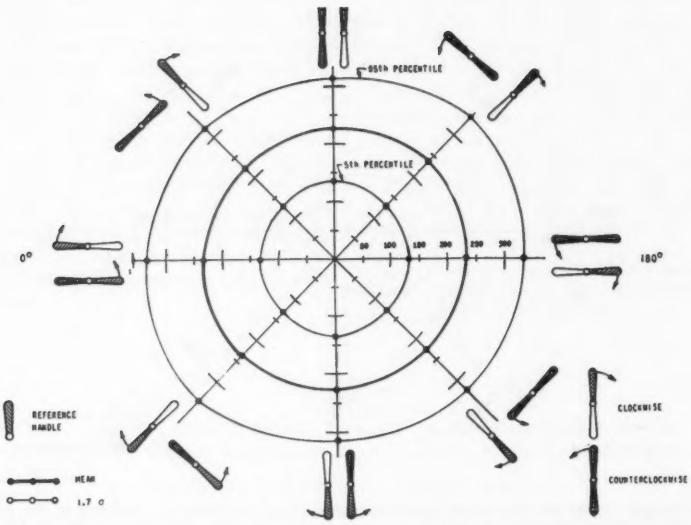

Fig 5. Absolute forces for operation of double L handles as reduced to the apparent point of application. Magnitude of forces in inch pounds at each 45° of rotation is illustrated by the radial distance from the center. Male subjects.

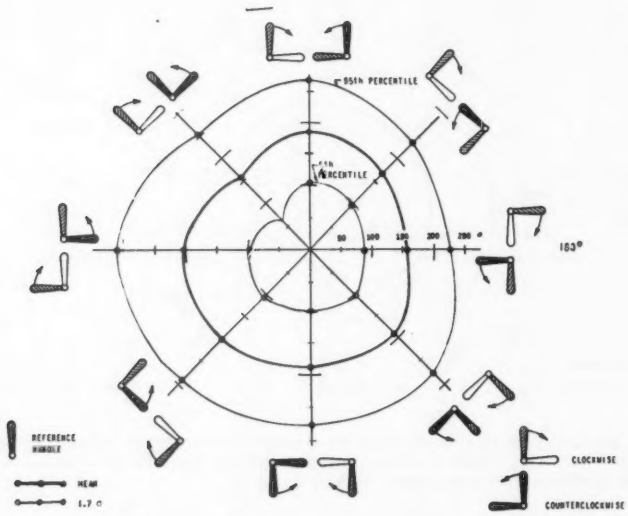

Fig 6. Absolute forces for operation of T handles as reduced to the apparent point of application. Magnitude of forces in inch pounds at each 45° of rotation is illustrated by the radial distance from the center. Male subjects.

A Follow-up Survey of Human Factors Research In Aircraft, Missiles, and Supporting Industries

J. A. KRAFT, Manager, Human Factors Research Department, Military Operation Research Engineering Division, Lockheed Aircraft Corporation, Marietta, Georgia.

A 1957 follow-up of a 1956 survey was made to determine the extent of human factors research in industry. More than 80% of the 56 companies contacted have human factors programs. The size of the human factors groups varied from one to thirty-four, with an average of ten, including professional, technical and administrative personnel. It is estimated that 700 people will be employed in human factors programs by 1960 in the companies surveyed.

INTRODUCTION

During August 1956, the author conducted a survey to determine the extensiveness of human factors research in airframe and related industries, e.g., missiles, helicopters, components.[1]

Forty representative companies were contacted in this survey and thirty-two responded. Only two of the thirty-two respondents indicated that they had no programs or plans for establishing one.

The responses indicated that more than 207 professional and technical personnel were engaged in human factors research activities in those companies having programs; they also indicated that the personnel would be expanded to 333 in the foreseeable future.

The survey also indicated that the growth rate of human factors programs, which started in 1951, began to increase rapidly in 1954.

[1]Kraft, J. A. and Vanderplas, J. M. "Human Factors Research in the Aircraft Industry". *The American Psychologist* 12:577-9 (Sept. 1957).

PURPOSE

In an effort to determine whether or not this accelerated growth was continuing, and to determine significant changes in direction of the programs, as well as the personnel composition of the human factors groups, a follow-up survey questionnaire was mailed in October 1957 to 37 of the companies previously contacted and to 19 additional companies.

FINDINGS

By February 1958, responses were received from 49 companies, two of whom were not contacted, but who learned of the survey and supplied the requested information. This represents an 84 percent response from the 56 companies surveyed. Nine failed to respond, but some information of their human factors activity is known to the author.

Organized Programs

Forty-three of the survey respondents now have human factors research programs or utilize the services of specialists in this field, and four of the nine companies failing to respond also are known to utilize such specialists. Thus, 81 percent of the companies included in the survey have human factors programs.

The following companies were contacted in this survey. An asterisk appears after the companies failing to respond:

American Power Jet Company*
Askania Regulator Company
AVCO, Crosley Division
Bell Aircraft, Buffalo
Bell Helicopter, Fort Worth
Bell Telephone, User Pref. Research, Murray Hill, N. J.
Bell Telephone, Military Engineering Department, Whippany, N.Y.
Boeing Airplane Company, Transport Division, Renton, Wash.
Boeing Airplane Company, Seattle
Boeing Airplane Company, Wichita
Bostrom Research Laboratory, Milwaukee*
Cessna Aircraft Company
Chance-Vought Aircraft, Inc.
Chrysler Corporation, Engineering Division, Detroit
Convair Aircraft, Fort Worth
Convair Aircraft, San Diego
Convair Astronautics, San Diego
Douglas Aircraft, El Segundo
Douglas Aircraft, Long Beach*
Douglas Aircraft, Santa Monica
Douglas Aircraft, Tulsa*
Eastman Kodak Company, Kodak Park Works, Rochester

Eclipse Pioneer Division, Bendix Aviation, Teterboro
Farnsworth Electronics Company
General Electric, Advanced Electronic Center, Ithaca
General Electric, HMEED Indus., Syracuse
General Electric, HMEED Syst. Util., Syracuse
General Electric, LMEED, Johnson City, N.Y.
General Electric, Missiles & ORD, Phila.
General Electric, TEMPO, Santa Barbara
Goodyear Aircraft Corporation
Hughes Aircraft, Ground Systems Division, Fullerton, Cal.
Hughes Aircraft, Culver City, Cal.*
IBM Corporation, Kingston Mil. Prod. Div., Lincoln Labs, Lexington, Mass.
IBM, New York, N.Y.
IBM, Owego, N.Y.
Lear Aircraft*
Litton Industries
Lockheed, California Division, Burbank
Lockheed, Georgia Division, Marietta, Ga.
Lockheed, MSD, Palo Alto, Sunnyvale, Cal.
Martin Company, Baltimore
Martin Company, Missiles, Denver*
McDonnell Aircraft, St. Louis
McDonnell Missiles, St. Louis
Minneapolis-Honeywell Regulator Company
Motorola, Inc., Riverside Res. Lab.
North American Aviation, Inc., Columbus
North American Aviation, Inc., Los Angeles
North American Aviation, Inc., Missiles Dev. Div., Downey, Cal.
Northrop Aircraft Corporation, Hawthorne, Cal.
Radio Corporation of America, Airborne Systems Lab., Waltham, Mass.
Republic Aviation Corporation*
Ryan Aero Company*
Sperry Gyroscope Company, Ronkonkoma, N.Y.
Stanley Aviation Company
Temco, Dallas, Texas*
Westinghouse Eclipse Corporation, Air Arm Division, Baltimore, Md.

Organizational Information

The majority of respondent companies with organized programs use the terms human factors or human engineering in their titles, with a decided preference for human factors. These groups are generally located within engineering organizational units. Most of the groups have line and staff responsibility; only a small number operate solely in a line capacity.

The reporting level of the groups is, primarily, two to three levels below the Chief Engineer. There is a great variation in the functional location of the groups within engineering, e.g., preliminary design, operations research, staff engineering, reliability, technical staff, advanced systems, and the like.

Size and Specialty Composition of the Groups

The average size of human factors research groups is ten professional, technical and administrative personnel, with a range from one person to thirty-four.

The specialty distribution and academic degree level, when reported, is as follows:

Specialty	No. of Degrees Within Specialty				
	No Degree	Bachelors	Masters	Doctors	TOTAL
Experimental Psychologists	2	14	31	52	99
Industrial Psychologists	0	0	8	10	18
Social Psychologists	0	0	0	2	2
Physiological Psychologists	0	0	1	0	1
Other Psychologists	0	5	5	3	13
Mechanical Engineers	6	36	6	1	49
Electrical Engineers	5	20	10	1	36
Aeronautical Engineers	2	5	0	0	7
Industrial Engineers	0	1	0	0	1
Other Engineers	3	4	1	0	8
Physicians	0	0	0	9	9
Physicists	0	8	6	0	14
Physiologists	0	2	3	7	12
Mathematicians	0	5	2	1	8
Statisticians	0	3	1	0	4
Anthropologists	0	3	3	0	6
Biophysicists	0	0	2	0	2
Industrial Designers	0	5	1	0	6
Other Professions	0	1	2	1	4
Pilots (No academic spec. given)	1	6	2	1	10
Engineering Technicians (No academic spec. given)	24	1	0	0	25
Administrative Personnel (No academic spec. given)	13	4	0	1	18
TOTAL	56	123	84	89	352

Present and Expected Strength

A total of 388 professional, technical and administrative people are engaged in human factors activities in the respondent companies, and an additional 183 are expected to be hired within the next two years.

Based on information from the previously referenced survey, an additional 60 are employed in the non-respondent companies, with a projected 40 people to be added.

Barring unforeseen developments, it is estimated that 700 people will be employed in human factors programs of the companies contacted by 1960.

Activities

Over 70% of the respondent companies claim to engage in experimental research activities. Sixty percent of these company programs depend, in part, on direct government contract support for their project efforts.

The work activity is widely diversified. A partial list of these activities, which follows, indicates the scope of the programs:

Crew station design
Missile control console design
Simulator testing
Psycho-acoustics research
Evaluation of human factors in air defense systems
Study of radar scope interpretation errors
Flight safety research
Studies of seat design and passenger compartment arangement
Evaluation of flight crew task loads
Display design, placement and illumination
Anthropometric determinations
Development of Qualitative Personnel Requirement Information
Determination of human tolerances to heat, noise, and g forces
Studies of human tolerance to confinement stress
Analysis of man-machine systems
Study of communication systems
Escape system research
Determination of operator response

CONCLUSIONS

- The rate of growth of human factors programs in the airframe and related industries is still continuing at an accelerated pace. At least 13 new programs have been started between August 1956 and December 1957. Only two of the major prime manufacturers do not have organized human factors programs, but it is known that both of these companies conduct some work in this area through their safety engineering and staff engineering organizations.
- A trend toward the designation of the activities as human factors research, rather than human engineering, seems apparent, but the figures are not conclusive at this time.
- Human factors groups generally tend to have a high reporting level within the engineering organizational structure; a group may function in a line capacity as well as in a staff capacity.
- In the industries surveyed, the number of people employed in this activity has increased by approximately 62% based on information received in the former survey and on the number of programs started in late 1956 and in 1957. Although in the latter part of 1957, there was some reduction in the numbers assigned to these groups, it is believed that this retrenchment was small.
- The average size of the groups has increased from 8.6 to 10 within one year, but the range of size of these groups has not increased beyond 34 people.
- The projected growth of these programs indicates that the groups will grow in size by 1960, and that as many as 700 will be employed in this activity in the companies surveyed.
- The specialties most frequently employed are experimental psychology, mechanical engineering, electrical engineering, industrial psychology, physics, and physiology, in that order.
- Advanced degrees are more generally required for the psychologists than for other specialties, with the Ph.D. predominant among the experimental and industrial psychologists and also among the physiologists.
- The majority of the companies conduct experimental research work, but judging from the list of activities, most would be classified as applied experimentation.
- The activities of the various groups, though broadened somewhat since 1946, do not appear to have changed in direction.

In summary, therefore, it appears that, despite the temporary setback in some programs during late 1957 due to defense expenditure cuts, the picture for the future development and expansion of human factors research programs is an optimistic one in the aircraft and related industries.

An Annotated Bibliography of Bibliographies Pertinent to the Design and Use of Machines by Human Operators*

PATRICIA S. ALLEN and **EZRA V. SAUL,** Institute of Applied Experimental Psychology, Tufts University, Medford, Mass.

This bibliography in the human factors field is based on the collection at Tufts University. A total of 117 references are given and discussed.

The present bibliography represents an initial collation from the files of the Human Engineering Information and Analysis Services Project, Tufts University. It has been prepared in the hope that it will be of some use to personnel in the human factors area in facilitating their acquisition of such items.

The references listed in this bibliography represent only a fraction of the total population of bibliographies which might have been listed. The failure to list many references containing extensive bibliographies is due to two primary restrictions: (1) Publications with extensive bibliographies were not listed if the primary objective of the report was not that of presenting a bibliography, (i.e., handbooks, textbooks, etc., were not included in the present listing). (2) Items were not listed in the present bibliography unless the document was available for examination by the authors.

In a number of citations, a university or industrial concern is presented within parentheses. This indicates that the research was conducted by the authors at that particular university or industrial location. In the case of a reference whose exact source is not certain, all available information is provided in the citation without the usual bold letter designation.

*Preparation of this paper was supported in part under Contract Nonr 494(13) between the Office of Naval Research and Tufts University.

The annotations accompanying the cited references are intended to convey the general content of the bibliography and are not intended to summarize any specific data, findings, etc., which may exist in the individual documents. The code information (*F.G.I.T.R.*) relates to the existence of figures, graphs, illustrations, tables and references contained in the individual documents. In the case of the *R* code, the number of references included in the document is also indicated, as G.I.R. 147.

Key to Abbreviations of Military and Governmental Sources

AFPTRC, ARDC: Air Force Personnel and Training Research Center, Air Research and Development Command, Lackland Air Force Base, Texas.
BuMed: Bureau of Medicine & Surgery, Department of the Navy, Washington, D.C.
BuPers: Bureau of Naval Personnel, Department of the Navy, Washington, D.C.
HRRC: Human Resources Research Center, Lackland Air Force Base, Texas.
HRRL: Human Resources Research Laboratory, Bolling Air Force Base, Washington, D.C.
NACA: National Advisory Committee for Aeronautics, Washington, D.C.
NADC: Naval Air Development Center, Johnsville, Penn.
NAMC, NAES: Naval Air Material Center, Naval Air Experimental Station, Philadelphia, Penn.
NRC: National Research Council, Washington, D.C.
ONR: Office of Naval Research, Washington, D.C.
WADC, ARDC: Wright Air Revelopment Center, Air Research and Development Command, Wright Patterson Air Force Base, Dayton, Ohio.

MILITARY AND GOVERNMENTAL SOURCES

1. Adams, Marjorie M. INDEX TO AIR FORCE PERSONNEL AND TRAINING RESEARCH CENTER: 1955 TECHNICAL DOCUMENTARY REPORTS. Res. Rep. AFPTRC-TN-55-84, Dec. 1955, 57pp. *Air Force Personnel and Training Research Center,* Lackland, AFB, Tex.

This index lists 99 technical documentary reports released in 1955 by the Air Force Personnel and Training Research Command. Included are 84 research reports, 1 technical report, and 14 Human Resources Research Insti-

tute Chinese technical research reports. Abstracts of the 84 research reports are included, as well as an author and subject index.
R 99

2. Air Force Cambridge Research Center. BIBLIOGRAPHY OF TECHNICAL PUBLICATIONS. Sept. 1955, 22pp. *Air Force Cambridge Research Center,* ARDC, Bolling AFB, Washington, D.C.

This is a cumulative bibliography of some 154 Unclassified, Confidential and Secret publications of the Operational Applications Laboratory (formerly Human Resources Research Laboratories, USAF, and Human Factors Operations Research Laboratories, Air Research and Development Command). The publication period is 1948-1955. In general the publications relate to the topics of training, audition, speech communication, survival, and safety.
R 154

3. Air Training Command. INDEX TO HUMAN RESOURCES RESEARCH CENTER PUBLICATIONS 1952. Dec. 1952. Technical Plans and Research Review Division, *Human Resources Research Center,* Air Training Command, Lackland AFB, Tex.

This report is a bibliography of 163 research reports, technical reports, conference reports, and research notes published by the Human Resources Research Center during the calendar year 1952. The research reports (59) are annotated. The citations relate almost exclusively to research on the selection and training of Air Force personnel.
R 163

4. Anon. ANNOTATED BIBLIOGRAPHY OF BILLET AND QUALIFICATIONS RESEARCH BRANCH STUDIES. JANUARY 1944-JUNE 1955. NavPers 18421, Sept. 1955, 49pp. Personnel Analysis Division, BuPers, Department of the Navy, Washington, D.C.

This annotated bibliography lists occupational and organizational research studies developed by the Billet and Qualifications Research Branch during the period January 1944 through June 1955. The bibliography is arranged according to the four major functions of the Branch as follows: occupational research, organizational research, occupational classification, and qualifications analysis. An index is included. A supplement covering the period July 1955 through July 1956 is inserted.
R 193

5. Anon. LIST OF PUBLICATIONS AVAILABLE THROUGH THE MEDICAL SAFETY DIVISION. STUDIES, ANALYSES AND PRESENTATIONS COMPLETED DURING 1952, 1953, 1954, AND 1955. Sept. 1955, 6pp *Directorate Flight Safety Research,* Office of the Inspector General, Norton AFB, Calif.

This is a list of published studies, analyses, and presentations by the Directorate Flight Safety Research, United States Air Force, Norton Air Force Base, California. The period covered is from 1952 through September 1955. The general area of research is flight safety and includes reports and analyses of accidents, studies on the use of emergency escape systems (canopies, ejection seats, parachutes) and of oxygen equipment, and reports on survival after bailout.
R 26

6. Army-Navy-NRC Vision Committee. A BIBLIOGRAPHY OF VISUAL LITERATURE 1939-1944, SUPPLEMENT. May 1947, 30pp. *Army-Navy-NRC Vision Committee,* Washington, D.C.

This bibliography lists reports and textbooks in the general areas of the physiology and psychology of vision, visual examination and testing, correction of ocular defects in military personnel, training for military specialties, ocular trauma, goggles and ocular protection, illumination, visibility, and military use and design of optical instruments and aids to vision. These areas are those listed in *A Bibliography of Visual Literature* for which additional reports have been placed in Army-Navy-NRC Vision Committee files. The time period covered is primarily 1945-1946.
R 293

7. ASTIA Reference Center. HUMAN ENGINEERING, A SELECTED BIBLIOGRAPHY AND A GUIDE TO THE LITERATURE. Rep. ARC 426U, Aug. 1953, 35pp. ASTIA Reference Center, Library of Congress, Washington, D.C.

This bibliography is a revision of an earlier report by the Navy Research Section entitled *Human Engineering; A Report Bibliography.* The revised form, consisting primarily of publications after 1949, includes a section of 36 bibliographic reports, as well as a second section of 325 annotated references in three general areas: experimental psychology, physiological psychology, and psychometrics.
R 325

8. Boes, Anita. BIBLIOGRAPHY OF RESEARCH REPORTS AND PUBLICATIONS ISSUED BY THE BIO-ACOUSTICS BRANCH (1947-1957). Sept. 1957, 22pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

This bibliography tabulates 164 publications from the research activities of the Bio-Acous-

tics Branch, Aero Medical Lab., Wright Air Development Center. Included are reports which have been published from 1947-1957 as technical reports, technical notes, memorandum reports and journal articles. The areas covered include topics such as: sound sources and noise fields, sound propagation, acoustic instrumentation, noise control, hearing and physiology of the ear, speech, biological and psychological effects of noise.
R 164

9. Bray, C. W. FINAL REPORT AND BIBLIOGRAPHY OF THE APPLIED PSYCHOLOGY PANEL, NDRC. Contract N6ori-199, OSRD Rep. 6668, June 1946, 66pp. National Defense Research Committee, Applied Psychology Panel, Washington, D.C.

   This bibliography lists 513 reports which were prepared as part of the work of the Applied Psychology Panel on the problems of selection, classification, and training of Service personnel and human needs and capacities in relation to the design and operation of military equipment. Of the total listing, 317 refer to formal reports and are listed in order of OSRD number. The remaining 196 reports are classified under the specific project numbers for which they were prepared.
   R 513

10. Brown, F. R., & Siegel, A. I. CAUTION AND WARNING LIGHT INDICATORS FOR NAVAL AIRCRAFT. I. A REVIEW OF THE PRESENT STATE OF THE ART. Contract N156s-33252, NAMC-ACEL-313, Oct. 1956, 72pp. *Naval Air Material Center,* Philadelphia, Penn.

    As part of a program to study the presentation of warning and cautionary information to pilots, the results of a survey of current presentation techniques, as well as a selected group of studies from the current literature, are discussed. The 24 references which are reviewed date from approximately 1941 through 1956.
    I. R 24

11. Fallon, D. ENGINEERING PSYCHOLOGY BRANCH BIBLIOGRAPHY. July 1957, 17pp. *Naval Research Lab.,* Applications Research Division, Washington, D.C.

    This bibliography lists in chronological order all unclassified reports issued by the Engineering Psychology Branch between its founding on October 1, 1945 and July 1957. Brief annotations are included for those reports of general scientific interest.
    R 93

12. Fox, H. G., Scott, W. D., Kirchner, W. K., & Mahoney, T. A. SELECTED ANNOTATED BIBLIOGRAPHY ON LEADERSHIP AND EXECUTIVE DEVELOPMENT. Contract 18(600)-320, Proj. 7730, Tech. Rep. 55-67, Task 77356, Dec. 1955, 70pp. *Officer Education Research Lab.,* AFPTRC, ARDC, Maxwell AFB, Ala.

    This bibliography on leadership and executive development represents an extensive search of journal literature through 1952. Aspects of the subjects which are covered are: summaries of literature, criteria of leadership, characteristics of leaders, executive jobs, selection of executives, and training and development of executivs. Annotations of 296 items (421 in all) containing objective research material are provided.
    R 421

13. Fulton, J. F., Hoff, Phebe M., Perkins, Henrietta T. (Ed.) A BIBLIOGRAPHY OF VISUAL LITERATURE 1939-1944. Publication II, Historical Library, Yale Medical Library, 1945, 201pp. Committee on Aviation Medicine, Division of Medical Sciences, National Research Council, Washington, D.C.

    This book presents a bibliography of the literature on vision that has relevance to military operations. The period covered is 1939 through 1944. Areas covered are: anatomy and ophthalmology, physiology and psychology, visual examination and testing (including methods and instruments), correction of ocular defects in military personnel, training for military specialties (including optimal conditions and procedures, job analyses), ocular trauma (in military services), goggles and ocular protection, illumination, and visibility. Author and subject indices are given and a brief description of the more active agencies in Great Britain, the United States, and Canada which have conducted research on visual problems.
    R 4886

14. Gatti, Jennie. REPORTS OF RESEARCH IN THE FIELD OF ENGINEERING PSYCHOLOGY. Proj. 7180, Tech. Rep. 56-154, April 1956, 35pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

    This bibliography lists titles and authors of reports published since 1945 by the Psychology Branch, Aero Medical Laboratory, Directorate of Research, Wright Air Development Center. The reports are listed by functional groupings.
    R 360

15. Dwin, A. C., & Wallis, D. SOME HUMAN FACTORS IN THE DESIGN OF CONTROLS: AN EVALUATION OF THE LITERATURE. Naval Motion Study Unit Rep. 61, Oct. 1954, 37pp. Office of Naval Research, Washington, D.C.

This review of the literature is intended as an extension of an earlier report (K.F.H. Murrell, Naval Motion Study Unit Rep. 36, 1948) on human factors relevant to control design. The topics discussed include: control-display direction-of-movement relationships, cranks and handwheels, control knobs, joysticks, foot pedals, distinguishability of controls, layout of controls, and anthropometric requirements. Principles for the design of controls are presented and recommendations for further research made.
T.F. R 47

16. Haythorn, W. W. A REVIEW OF RESEARCH ON GROUP ASSEMBLY. Proj. 7713, Rep. AFPTRC-TN-57-62, Task 57165, May 1957, 14pp. *Crew Research Lab.,* AFPTRC, ARDC, Randolph AFB, Tex.

This report reviews the literature regarding group assembly by nomination techniques, homogeneity of group members, distribution of technical and social skills, and the interaction of personalities. In addition, mathematical problems in group assembly are discussed. Principles of group assembly and recommendations for the assembly of Air Force crew are presented.
R 39

17. Headquarters, Air Material Command. SELECTED LISTING OF AIR TECHNICAL PUBLICATIONS. June 1947, 30pp. *Air Materiel Command,* Wright Field, Dayton, Ohio.

This bibliography is a selected listing of approximately 356 air-technical publications consisting primarily of translations of captured German documents and various types of air-technical intelligence reports. These reports cover such areas as: areodynamics, aeromedicine, aircraft, electronics, equipment, guided missiles, hydrodynamics, high altitude flight, materials, power plants, landing and take-off, armor and armament.
R 356

18. Hoff, E. C., & Greenbaum, L. J. Jr. A BIBLIOGRAPHY SOURCEBOOK OF COMPRESSED AIR, DIVING AND SUBMARINE MEDICINE. VOL. II. NAVMED P-5033, Nov. 1954, 368pp. BuMed, Office of Naval Research, Washington, D.C.

This is a sourcebook of references to the literature in medical problems of diving, compressed-air work, and submarine operations. Citations comprise unclassified reports and documents as well as books, monographs and papers appearing between 1 January 1946 and 31 December 1951. Some references not available for Volume I (1946) are included. The contents are classified as to general studies of submarine medical problems, technical procedures and research apparatus, special anatomy, physiology, and biochemistry, biology of very high hydrostatic pressures, diseases and accidents in personnel, protection and preservation of personnel, selection and training of personnel, special psychological and psychiatric problems and special problems of skin-diving. Indices of authors, sources for unpublished reports, and of subjects are included.
R 3807

19. Horigan, F. D. HUMIDITY STUDIES. Bibliographic Series No. 19, Nov. 1951, 34pp. *Quartermaster Research and Development Lab.,* Technical Library, Natick, Mass.

Studies of the measurement, control and effects of ambient humidity are listed in an annotated bibliography, which includes investigations related to instrumentation, foods, pest control, metals, packaging, physical chemistry, physiology, plastics, leather and textiles.
R 119

20. Horigan, F. D., & Sage, C. R. SOME PHASES OF PERSPIRATION. Technical Library Bibliographic Series No. 17, Jan. 1951, 37pp. *Quartermaster Research and Development Lab.,* Philadelphia, Penn.

This is a list of 130 titles from publication period 1939-1949 pertinent to human perspiration. The titles are classified under such headings as: effect of environment on perspiration; effect of perspiration on fabrics, leather, metals and finishes; perspiration, vitamins and nutrition; perspiration as antibiotic and antiseptic; composition and biochemistry of perspiration; and anti-perspirants and deodorants.
R 130

21. Jacobius, A. J. & Wilkins, Madeleine J. AVIATION MEDICINE: AN ANNOTATED BIBLIOGRAPHY, 1952 LITERATURE. Government Order NAonr-211-56, Nov. 1956, 204pp. Technical Information Division, The Library of Congress, Washington, D.C.

This is an extensive annotated bibliography of the 1952 literature pertinent to the general area of aviation medicine. The specific topics reflected among the various citations include the following: pilot instrument design, air safety, special environmental effects, protective clothing, motion sickness, tactual discrimination of knobs, depth perception, etc. A subject index is included.
R 500 (approximately)

22. Kappauf, W. E. STUDIES PERTAINING TO DESIGN OF VISUAL DISPLAYS FOR AIRCRAFT INSTRUMENTS, COMPUTERS, MAPS,

CHARTS, TABLES AND GRAPHS: A REVIEW OF THE LITERATURE. Contract W33-038-ac-14480, TR 5765, April 1949, 100pp. *Aero Medical Lab.*, Engineering Division, WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

This is a review of the literature relating to problems of design and use of certain visual displays in aircraft. Types of sources used are personal experience and opinion, psychological and physiological literature on vision and perception, and applied research on specific design problems. Various sections are devoted to (1) problems of research, (2) characteristics of human vision and perception important to the design of visual displays, (3) problems specific to the design of instruments, and (4) computers, maps, charts, tables, and graphs. *G.I.R. 315*

23. King, S. H., Hoyt, W. G., Marks, M. R., & Roy, H. L. SURVEY OF LITERATURE ON DEVELOPMENT OF CRITERIA FOR MARGINAL MANPOWER. PRB Proj. D-13-281-01, DA Proj. 295-60-000, PRB Tech. Res. Note 54, March 1956, 13pp. Personnel Research Branch, Adjutant General's Office, Washington, D.C.

To measure the contribution made by men of limited mental capacity in a military situation, the authors reviewed publications of government agencies and in the open literature. In addition, personnel engaged in research on the training and utilization of marginal manpower were interviewed. Findings are discussed in terms of the availability of previous research studies, kinds of measured performance differences between marginals and "normals" and the meaningfulness of such differences. Recommendations for specific research are presented. *R 36*

24. Kohl, Jessie W. CUMULATIVE BIBLIOGRAPHY OF RESEARCH REPORTS AND PUBLICATIONS ORIGINATING IN U.S. NAVAL MEDICAL RESEARCH LABORATORY, 1942 THROUGH 1950. May 1951, 53pp. *Medical Research Lab.*, Naval Submarine Base, New London, Conn.

This report contains a chronological listing of 169 Naval Medical Research Laboratory reports from 1942 to 1950. Seventy additional reports, which are not integrated into the author or subject indices, are listed from 1951 through 1953. Also included are reports and publications issued from the Medical Research Laboratory's Sound Section, Vision Section, Physiological Section, Personnel Selection Section, and Statistical Section. These sections contain items from the chronological listings, as well as additional articles published in scientific journals by staff members of the various sections. *R 240* (approximately)

25. Kreezer, G. L., Hill, J. H., & Manning, W. ATTENTION. A BIBLIOGRAPHY AND CLASSIFICATION OF THE PSYCHOLOGICAL LITERATURE. Contract AF 33(616)-135, TR 54-455, Aug. 1954. *Aero Medical Lab.*, WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

This bibliography contains 543 references on the topic of attention which are indexed under such project headings as Measurement of Attention, Phenomenological and Introspective Studies, Special Phenomena of Attention, Physiological Correlates of Attention, Differential Psychology of Attention, and Applied Problems of Attention.

26. Lawrence, M., & MacMillan, J. W. ANNOTATED BIBLIOGRAPHY. ON HUMAN FACTORS IN ENGINEERING DESIGN. Proj. X-651 (Av-340-a), Feb. 1946, 209pp. BuMed, Aviation Branch, Research Division, Department of the Navy, Washington, D.C.

This annotated bibliography was prepared "to furnish information to engineers and research workers regarding human abilities that may have use in the design of machines and informational devices . . ." The 407 references are listed under such topic headings as: Anthropometric Data, Physiology, Psychology, Instruments, Controls, Work Place, Group Operation, and Bibliographies. An author and subject index are provided. *R 407*

27. Lecznar, Margaret W. INDEX TO HUMAN RESOURCES RESEARCH CENTER PUBLICATIONS 1949-1951. Contract N6ori-199, Res. Bull. 51-35, Dec. 1951, 31pp. *Human Resources Research Center*, Air Training Command, Lackland AFB, San Antonio, Tex.

This is a bibliography of 129 Research Bulletins, Conference Reports, and Research Notes published by the Human Resources Research Center during the calendar years 1949-1951. The Research Bulletins (39) are annotated. The references relate almost exclusively to research on the selection and training of Air Force personnel. *R 129*

28. Leikind, M., & Weiner, J. VISIBILITY: A BIBLIOGRAPHY. July 1952, 90pp. Library of Congress, Reference Dept., Tech. Information Division, at request of Armed Forces-NRC Vision Committee and the Office of Naval Research, Washington, D.C.

This bibliography provides references gained from a survey of literature (1925-1950) on visibility as influenced by the various physical,

psychological, and physiological factors inherent in the observer, target, background and atmosphere, and the engineering applications of visibility data.
R 2008

29. Lockard, R. B. BIBLIOGRAPHY OF HUMAN ENGINEERING REPORTS ON TRACKING. NOTS 744, NAVORD Rep. 5272, April 1956, 88pp. Instrument Development Division, *Naval Ordnance Test Station,* China Lake, Calif.

This report is a bibliography of human engineering reports on tracking. The concept of a power-driven tracking instrument is implicit throughout, and the order of categories roughly follows a theoretical tracking loop. Topics covered are: target characteristics, display characteristics, the human, tracking instrument controllers, control-display relationship, apparatus, and general tracking.
R 600 (approximately)

30. Medical Nutrition Laboratory. BIBLIOGRAPHY — REPORTS TO THE SURGEON GENERAL. c1955, 14pp. *Army Medical Nutrition Lab.,* Fitzsimons Army Hospital, Denver, Colo.

This is a bibliography of 172 reports from the Medical Nutrition Laboratory. The reports are listed chronologically from 1945 through 1955.
R 172

31. Marsh, J. E., & Wilder, Eleanor W. IDENTIFYING THE EFFECTIVE INSTRUCTOR: A REVIEW OF THE QUANTITATIVE STUDIES, 1900-1952. Proj. 7714, Task No. 77243, Res. Bull. AFPTRC-TR-54-44, Oct. 1954, 151pp. *Training Aids Research Lab.,* AFPTRC, ARDC, Chanute AFB, Ill.

This report presents a literature research covering 392 references on quantitative studies related to identifying the effective instructor. The literature review, extending over the period 1900-1952, is divided into four broad areas: principal findings of cited research studies, criteria of instructor effectiveness, predictors of instructor effectiveness, and implications for further research.
T.R 392

32. National Advisory Committee for Aeronautics. LIST OF NACA REPORTS 1947-1951. 18pp. *National Advisory Committee for Aeronautics,* Washington, D.C.

This is a listing of 196 NACA reports from 1947-1951, exclusive of technical notes and technical memoranda. Included are report titles, authors, and reprint prices.
R 196

33. National Research Council-National Academy of Sciences. BIBLIOGRAPHY OF THE SUBMARINE 1557-1953. Publication 307, March 1954, 261pp. Committee on Undersea Warfare, *Naval Research Lab. — National Academy of Sciences,* Washington, D.C.

This bibliography, compiled to bring together the mass of unclassified material on submarine development (1557 through 1953), is divided into eight sections: general and historical nontechnical; special types of submarines; design and construction; operations; maintenance, repairs, and related faciilties; the submarine in war; antisubmarine warfare; data books. The emphasis in this report is on submarine development per se, rather than on a comprehensive search of the great mass of related technical data.
R 500 (approximately)

34. Naval Air Development Center. ACCOMPLISHMENT SUMMARY OF AVIATION MEDICAL ACCELERATION LABORATORY. 1954, 32pp. *Aviation Medical Acceleration Lab.,* NADC, Johnsville, Penn.

This report summarizes research at the Aviation Medical Acceleration Laboratory, Naval Air Development Center. Illustrations and description of the human centrifuge and its use in research are included. Other topics presented are G-protective devices, effect of physical stress on physiological factors, activities of the Biochemistry Laboratory, x-ray motion pictures, activities of the Psychophysiology Division and the Pathology Laboratory. Library facilities, university affiliations, and publications of the laboratory are given.
T.G.I.R 12

35. Naval Air Material Center. CHRONOLOGICAL LIST OF REPORTS. March 1955, 5 pp. *Aero Medical Equipment Lab.,* Human Engineering Branch, NAMC, Naval Air Experimental Station, Philadelphia 12, Penn.

This bibliography is a chronological listing of Naval Air Material Center reports concerned with problems of aircraft lighting and visual displays. The period covered is from July 1945 to February 1955.
R 54

36. Navy Electronics Laboratory. NEL HUMAN FACTORS DIVISION REPORTS; LIST OF. Jan. 1956, 21pp. *Navy Electronics Lab.,* San Diego, Calif.

This is a bibliography of some 300 Unclassified and Confidential reports and technical memoranda published by the Human Factors Division, U.S. Naval Electronics Laboratory, since its establishment in 1946. The listed titles

relate to Audiometry, Psycho-acoustics, Sonar selection and training, etc.
R 300 (approximately)

37. Office of Naval Research. AIRCRAFT INSTRUMENTATION DATA PRESENTATION AND HUMAN ENGINEERING SURVEY. PROGRAM FOR DEVELOPMENT OF INTEGRATED PRESENTATION OF FLIGHT INFORMATION: UNITERM COORDINATE INDEX. Contract Nonr 1908(00). References 1-4099. c1954. *Office of Naval Research,* Documentation Inc., Washington 8, D.C.

This volume, to be used with its companion work of abstracts (see No. 38), is the Uniterm Coordinate Index to publications concerned with aircraft instrumentation, data presentation, and human engineering. It contains retrieval words (uniterms) for unclassified abstracts arranged in numerical and alphabetical order. Names of instruments, manufacturers, governmental agencies, and other sources, as well as the basic working vocabulary of the fields, are included. An author index follows the Uniterm index. Instructions for the most effective usage of the index are included.
R 2500

38. Office of Naval Research. AIRCRAFT INSTRUMENTATION DATA PRESENTATION AND HUMAN ENGINEERING SURVEY. PROGRAM FOR DEVELOPMENT OF INTEGRATED PRESENTATION OF FLIGHT INFORMATION. Contract Nonr 1908(00). References 1-4099. Feb. 1954, 235pp. *Office of Naval Research,* Documentation, Inc., Washington 8, D.C.

This compilation of annotated references, with its Uniterm Coordinated Index (see No. 37) is a working tool for research and development in the Program for the Development of Integrated Presentation of Flight Information. Code letters are given for each abstract which identify the source for ordering the document and the source or agency responsible for the work.
R 2500

39. Office of Naval Research. BIBLIOGRAPHY OF UNCLASSIFIED RESEARCH REPORTS. June 1956, 46pp. Personnel and Training Branch, Psychological Sciences Division, *Office of Naval Research,* Washington, D.C.

This bibliography includes unclassified reports relating primarily to personnel and training. The reports are grouped under the following general headings: (1) isolation and measurement of basic psychological traits; (2) selection and classification problems; (3) billet analysis and billet classification research; (4) performance criteria; and (5) training and education research.
R 300 (approximately)

40. Office of Naval Research. BIBLIOGRAPHY OF UNCLASSIFIED RESEARCH REPORTS. SUPPLEMENT NO. 1: JUNE 1956-JUNE 1957. June 1957, 12pp. Personnel and Training Branch, Psychological Sciences Division, *Office of Naval Research,* Washington, D.C.

This bibliography lists unclassified research reports produced by the Personnel and Training Branch of the Psychological Sciences Division, Office of Naval Research, for the period June 1956 to June 1957. Major topics are: isolation and measurement of basic psychological traits, selection and classification problems, performance criteria, and training and education research.
R 102

41. Office of Naval Research. BIBLIOGRAPHY OF UNCLASSIFIED RESEARCH REPORTS. SUPPLEMENT NO. 3: JULY 1956-JULY 1957. July 1957, 12pp. Physiological Psychology Branch, Psychological Sciences Division, *Office of Naval Research.* Washington, D.C.

This bibliography of physiological and psychological reports covers the period July 1956-July 1957. Five areas (31 research contracts) are covered: (1) psychophysiology of sensory mechanisms—vision, audition, chemoreception, mediation of vibratory forces; (2) problems of perception and orientation in space — visual acuity for moving objects, visual perception of space and motion, factors in human orientation and disorientation, voice communication; (3) neurophysiological aspects of performance — studies of the brain and human behavior, autonomic and central nervous system, muscle system, hearing losses; (4) psychophysiological factors in human tasks — display, control and transmission of information both visual and auditory, tracking performance; and (5) effects of high intensity noise.
R 137

42. Office of Naval Research. BIBLIOGRAPHY ON MOTION SICKNESS. Joint Services Committee Rep. 2, ONR Rep. ACR-3, Jan. 1956, 29pp. Physiological Psychology Branch, Psychological Sciences Division, *Office of Naval Research,* Washington, D.C.

This bibliography on motion sickness represents the literature up to and through the year 1954. Compilation was made preliminary to organizing a comprehensive study of the evaluation of drug protection against motion sickness in its many forms. References were selected that were

felt to be of value to those concerned with the broad organization of the study as well as those undertaking various aspects of the program.
R 525 (approximately)

43. Office of Naval Research, Physiological Psychology Branch. BIBLIOGRAPHY OF RESEARCH REPORTS — SUPPLEMENT NO. 2: JULY 1955-1956. July 1956, 15pp. Psychological Sciences Division, Physiological Psychology Branch, *Office of Naval Research,* Washington, D.C.

This report is Supplement number 2 (July 1955-1956) to the ongoing bibliography of research reports from the Physiological Psychology Branch, Office of Naval Research. Included in this supplement are 202 technical reports from 41 research projects.
R 202

44. Office of Naval Research, Psychological Sciences Division. BIBLIOGRAPHY OF RESEARCH REPORTS 1 JANUARY 1947-1 JANUARY 1954. March 1954 36pp. Psychological Sciences Division, Physiological Psychology Branch, *Office of Naval Research,* Washington, D.C.

This bibliography lists reports published under the aegis of the Psychological Sciences Division, Office of Naval Research, during the period Jan. 1954-June 1955. Some 190 references are listed under such topic headings as: Voice Communications; Display, Control, and Transmission of Information; Display and Signal Pattern Discrimination; Physiological Acoustics; Visual Perception of Space and Motion, etc.
R 186

45. Office of Naval Research, Naval Research Advisory Panel in Psychophysiology. PSYCHOPHYSIOLOGICAL FACTORS IN SPATIAL ORIENTATION. NAVEXOS P-966, Oct. 1950, 89pp. Psychophysiology Branch, *Office of Naval Research,* Washington, D.C.

This is a complete report of the Symposium on Psychophysiological Factors in Spatial Orientation, including ten experimental research papers covering neurophysiological factors, orientation to visual and postural vertical and accelerative forces and three theoretical research papers. Distributed over the 13 papers are 65 references.
R 65

46. Parker, Judith T., Austin, T. R., Bond, H. J., & Bricker, P. D. ANNOTATED BIBLIOGRAPHY OF REPORTS ISSUED BY THE PSYCHOLOGICAL AND ENGINEERING LABORATORIES, THE JOHNS HOPKINS UNIV., UNDER CONTRACT N5-ORI-166, TASK ORDER 1. Rep. 166-1-170, Sept. 1953, 102pp. Office of Naval Research, *Special Devices Center,* Port Washington, L. I., N. Y.

This report presents an annotated bibliography of 155 research reports issued by the psychological and engineering laboratories of The Johns Hopkins University since 1946. The reports are listed under seven headings: sensory processes, motor skills, methods, scale reading and dials, equipment, visual displays, and systems research. Both classified and unclassified reports are included. An author index and a subject index are included.
R 155

47. Quartermaster Food & Container Institute for the Armed Forces. THIRST AND WATER BALANCE IN SURVIVAL CONDITIONS. BIBLIOGRAPHY 1948. 18pp. *Quartermaster Food & Container Institute for the Armed Forces,* Chicago, Ill.

This bibliography includes English and foreign language publications on thirst and water balance in survival conditions. The period covered is from 1900 (approximately) to 1948.
R 287

48. Quartermaster Research and Development Command. BIBLIOGRAPHY OF PUBLICATIONS AND TECHNICAL PAPERS FOR 1956. Tech. Rep. QMRD-12, Feb. 1957, 31pp. *Quartermaster Research and Development Center,* Natick, Mass.

This report lists 332 publications and technical papers resulting from research conducted by the Quartermaster Research and Development Command during 1956.
R 332

49. Robinette, Joan C. A SELECTED BIBLIOGRAPHY CONCERNING PHYSIOLOGICAL FACTORS IN AERO-MEDICAL RESEARCH AND DEVELOPMENT. April 1957, 42pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

This is a bibliography of the project work conducted by the Physiology Branch of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center. The principle topics include thermal physiology and protective garments; toxicity of materials and toxic chemical measurement; respiratory physiology and high altitude protective garments; aircraft visual requirements; nutrition and metabolism. The period covered is from 1940 to 1957. Included are memorandum and technical reports and notes and handbooks.
R348

50. Siegfried, Margaret. BIBLIOGRAPHY OF RESEARCH REPORTS ISSUED BY THE BIOPHYSICS BRANCH. Jan. 1957, 14pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio.

This bibliography lists those publications — technical reports, technical notes, memorandum reports, and papers—that are considered to be of lasting interest in the fields of research conducted by the Biophysics Branch of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center. The time period covered is from 1946 through 1956 and only articles now published are included. The areas covered are: acceleration, anthropology, bioelectronics, escape, stress and fatigue.
R 116

51. Special Devices Center. BIBLIOGRAPHY OF HUMAN ENGINEERING REPORTS (UNCLASSIFIED). NAVEXOS P-1491, Jan. 1956, 18pp. Office of Naval Research, *Special Devices Center,* Port Washington, L. I., N.Y.

This is a bibliography of unclassified human engineering reports revised as of January 1956. The 424 reports listed are distributed over ten areas as follows: learning, 95; motor skills, 65; perception, 64; voice communications, 57; extreme environmental factors, 5; systems analysis, 25; controls and displays, 28; training devices, 60; research tools, 20; general human engineering, 5.
R 424

52. Technical Information Division, Library of Congress. THE POLAR BIBLIOGRAPHY, VOLUME I. AFM 200-132, DA Pamphlet 70-1, OPNAV Instruction 3470.3, NAVMC 1127, Aug. 1956, 223 pp. Department of Defense, Washington, D.C.

The Polar Bibliography includes informative abstracts of all types of information relating to polar and sub-polar regions; data on experiments, tests and performance of equipment now in use or proposed for use in these regions; operational information and cold weather techniques; and data relating to man in cold environment. Sources used include formal staff reports, staff studies and memoranda for the record, as well as other unpublished papers, pamphlets, manuals and books prepared by the military and issued since 1939. A detailed subject index has been provided.
R 1000

53. USAF School of Aviation Medicine. SUBJECT INDEX OF SCHOOL OF AVIATION MEDICINE RESEARCH REPORTS. Jan. 1942-Dec. 1956, 72pp. *School of Aviation Medicine,* Randolph AFB, Tex.

This index contains titles of research reports published by the School of Aviation Medicine from 1942 through 1956. The subject headings are arranged by major fields of interest with sub-headings under each field. These major fields are: accidents, air evacuation, aviation medicine, dentistry, internal medicine, microbiology, neuropsychiatry, ophthalmology, otolaryngology, pathology, personnel, pharmacology and biochemistry, physiology, psychology (clinical and experimental), radiobiology, space medicine, statistics (medical), preventive medicine, surgery and anesthesiology, veterinary sciences, and miscellaneous.
R 1280 (approximately)

54. US Naval School of Aviation Medicine. PROGRESS REPORT AND THE RESULTS OF A DECADE OF RESEARCH AT THE SCHOOL OF AVIATION MEDICINE. May 1953, c75pp. *Naval School of Aviation Medicine,* Pensacola, Fla.

Included in this progress report, presenting the results of a decade of research (1943-1953) at the School of Aviation Medicine, are 308 reports listed under such classifications as: history and general aspects of aviation medicine, the special physiology of aviation and conditions simulating flight, the special pharmacology of aviation and conditions simulating flight, diseases and accidents in aviation and conditions simulating flight, selection and assessment of efficiency of flight personnel, training, performance and fatigue of flight personnel, etc. Also included are 53 research progress reports as of December 31, 1952.
R 361

55. Weiss, Sylvia E., & White, H. S. A CATALOG OF OSRD REPORTS — DIVISION 7, FIRE CONTROL. Contract NAonr 13-47, PB 104375s8, July 1952, 44pp. Office of Naval Research. (Distributed by Office of Technical Services, U.S. Dept. of Commerce, Washington, 25, D.C.)

This is a catalog of OSRD reports in Division 7 (fire control). Approximately 400 unclassified reports are listed according to contracting agency. A contractor index, an author index and a subject index are included.
R 400 (approximately)

56. Wulsin, F. R. RESPONSES OF MAN TO A HOT ENVIRONMENT. Rep. 139, Dec. 1948, 61pp. Environmental Protection Section, *Office of Quartermaster General,* Washington, D.C.

This paper reviews the various aspects of heat stress as it is likely to affect soldiers in the

tropics, with particular reference to design of clothing and equipment. The problem is considered in seven general areas: metabolism; storage; evaporation; radiation; convection; conduction; behavior of the body under heat stress. Fifty-nine references, selected from 1915-1947, are included.
T.I.R. 59

UNIVERSITY SOURCES

57. Andreas, B. G. BIBLIOGRAPHY OF PERCEPTUAL-MOTOR PERFORMANCE UNDER VARIED DISPLAY-CONTROL RELATIONSHIPS. Contract AF30(602)-200, Scientific Rep. 1, June 1953, 17pp. Human Factors Office, *Rome Air Development Center,* Griffiss AFB, Rome, N.Y. (University of Rochester).

This report reflects the published literature from 1943-1952 and contains 136 references distributed as follows: 32 general references on perceptual-motor performance, human engineering and man-machine systems; 10 references on the relationships between discrete display elements and discrete control movements; 61 references relating direction and plane of movement in displays and controls; 24 references on the ratio between extent of movement of controls and resulting movement of display; and 9 references on velocity rate aided and acceleration control.
R 136

58. Andreas, B. G., & Weiss, B. REVIEW OF RESEARCH ON PERCEPTUAL-MOTOR PERFORMANCE UNDER VARIED DISPLAY-CONTROL RELATIONSHIPS. Contract AF 30(602)-200, May 1954. Human Factors Office, *Rome Air Development Center,* Griffiss AFB, Rome, N.Y. (University of Rochester).

59. Andrews, T. G., & Ross, S. SUMMARY REPORT ON STUDIES OF BEHAVIORAL EFFICIENCY (1951-1954). Contract DA-49-007-MD-222, Jan. 1955, 28 pp. *Army Medical Research and Development Board,* Office of the Surgeon General. (University of Maryland).

This report reviews and summarizes 27 separate technical reports pertinent to various aspects of behavior decrement and individual performance efficiency in the general field of human engineering. Eight of the reviewed reports are "Reviews of the Literature" and the remaining reviewed reports relate to experimental research directed by the authors. Topics receiving emphasis are: fatigue induced by sleep deprivation, exercise, length of performance, etc.; and stress effects induced by anxiety, instruction, speed, and display-control arrangements.
R 27

60. Ashenhurst, F. F. SYSTEMS ANALYSIS LITERATURE. Contract Nonr 494(03), Rep. 1954-494-03-17, April 1954, *Office of Naval Research.* (Tufts College).

This report summarizes work on the problem, Systems Analysis Literature, surveys the areas of systems analysis and coordination, and presents four separate bibliographies. The two major bibliographies cover 206 references from unclassified systems literature, and approximately 1000 references from classified systems literature. The third bibliography is an example of a functional bibliography for a cathode ray tube handbook covering about 150 references. The fourth is an example of an annotated bibliography for systems literature and includes 17 references.
R 1373 (approximately)

61. Barch, A. M., Haggard, D. F., Seiden, H., Vineberg, R., et. al. A BIBLIOGRAPHY OF HUMAN FACTORS IN RADAR OPERATION AND MAINTENANCE. Sept. 1953, 43pp. *Human Resources Research Office,* The George Washington University.

This bibliography was compiled as a source of reference information on radar needs and requirements from the point of view of human resources research. Psychological, military, and engineering literature are included. Major categories covered are: (1) reviews and bibliographies; (2) radar operator research—training and training aids, visual effects of radar operation, operating conditions, selection, proficiency measurement; (3) human engineering; (4) electronic maintenance; and (5) peripheral, basic and methodological.
R 431

62. Batchelor, J. H. OPERATIONS RESEARCH — A PRELIMINARY ANNOTATED BIBLIOGRAPHY. 1952, 95pp. *Case Institute of Technology.*

This report containing 309 annotated references, was prepared as a guide to the existing literature on Operations Research. Both American and foreign reports, published primarily between 1945 and 1951, are included.
R 309

63. Bowen, J. H., Hussman, T. A., & Lybrand, W. A. A REVIEW OF THE LITERATURE ON INDUCED SYSTEMATIC FATIGUE. Proj. DA-49-007-MD-222, (O.I. 19-52), Tech. Rep. 7, March 1952, 13pp. *Army Medical Research and Development Board,* Office of the Surgeon General. (University of Maryland).

A review of the literature on general systematic fatigue is presented in this report. Problems of definition are discussed and methods of inducing fatigue reviewed. These latter include sleep deprivation, work periods, ergographic work, psychomotor tasks. On the basis of the review recommendations are made regarding the use of operationally defined decrement-producing variables for a research problem.
R 94

64. Cheatham, P. G. A COMPARISON OF THE VISUAL AND AUDITORY SENSES AS POSSIBLE CHANNELS FOR COMMUNICATION. Contract W33-038-ac-21269, TR 5919, May 1950, 28pp. *Air Materiel Command,* Wright-Patterson AFB, Dayton, Ohio. (University of Virginia).

This report presents a review of the literature relevant to a research program comparing the relative efficiency of the visual and auditory senses for communication purposes. The 139 references are distributed as follows: vision, 84; audition, 45; comparison of the two senses, 4; sensory interaction, 3; additional, 3.
R 139

65. Colby, Helen J., & Garn, S. M. A BIBLIOGRAPHY ON MILITARY AND INDUSTRIAL APPLICATIONS OF ANTHROPOMETRY AND APPLIED PHYSICAL ANTHROPOLOGY. Contract DA 18-108-cml-2829, Supplementary Rep. 11, Jan. 1952, 17pp. *Forsyth Dental Infirmary for Children,* Tufts University.

This bibliography lists 124 references on applied anthropometry and anthropology, distributed under eight subheadings as follows: general, 33; general body size, 33; models, manikins and headforms, 6; face and head size, 9; limb and hand size, 14; seating, 11; kinematics, 12; calorimetry, 6.
R 124

66. Conduit, D. M. A SYSTEM FOR HANDLING DATA ON UNCONVENTIONAL WARFARE (U).—INCLUDING A BIBLIOGRAPHY OF OPEN SOURCES. ORO Stud. 23. 5, TM ORO-T-339, May 1956, 185pp. Logistics Division. *Operations Research Office.* (The Johns Hopkins University).

This document outlines a system for treating data on unconventional warfare so as to make such data available for immediate research. Mechanical information-holding systems, the IBM and addressograph machines, are compared with non-mechanical ones, the card catalogue and keysort systems. Included is an extensive bibliography of open sources on the topic of unconventional warfare.
I.R 1036 (approximately)

67. Day, W. F., & Beach, Barbara R. A SURVEY OF THE RESEARCH LITERATURE COMPARING THE VISUAL AND AUDITORY PRESENTATION OF INFORMATION. Contract W33-038-ac-21269, Tech. Rep. 5921, c.1951, 14pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio. (University of Virginia).

This report, presenting a summary of the research literature comparing visual and auditory presentation of information, includes a bibliography of 34 references in the area. The literature, from both American and foreign sources, covers a publication period from 1896-1946.
R 34

68. Devoe, D. B. BIBLIOGRAPHY ON USES OF HIGH-SPEED COMPUTERS IN PSYCHOLOGY. Aug. 1957, 4pp. IBM Associateship Program, *Massachusetts Institute of Technology Computation Center.* (Institute for Applied Experimental Psychology, Tufts University).

This bibliography on the uses of high-speed computers in psychology covers a period from 1949 through May 1957. Journal reports and books are included.
R 45

69. Fletcher, J. L., & Ross, S. TESTS OF STEREOSCOPIC VISION: A REVIEW. *Quart. Rev. Ophthalmol.,* 1953, *166,* 551-62. (Department of Psychology, University of Maryland).

In this review, seven recent tests of stereo vision and five tests of depth perception which have been reported in the scientific literature are described and evaluated in terms of such criteria as reliability, validity, and objectivity. The bibliography consists of 46 references published from about 1900-1953.
R 46

70. Greenhill, L. P. (Coordinator). A BIBLIOGRAPHY OF PRODUCTION, UTILIZATION, AND RESEARCH ON INSTRUCTIONAL FILMS. Contract N6onr-269, Proj. 20-E-4, Tech. Rep. SPECDEVCEN 269-7-40, Nov. 1953, 145pp. *Special Devices Center,* Port Washington, L. I., N. Y. (Instructional Film Research Program, Pennsylvania State University).

This is an extensive bibliography of research studies on the production, use and evaluation of instructional films up to 1952. Some references are included which are indirectly re-

lated to instructional films, for example, articles and books dealing with radio, music, learning theory, research methods, etc.
R 1500 (approximately)

71. Hake, H. W. CONTRIBUTIONS OF PSYCHOLOGY TO THE STUDY OF PATTERN VISION. Contract AF 33 (616)-2918, Proj. 7192 — 71598, Oct. 195,7, 118pp. *Aero Medical Lab.,* WADC, ARDC, Wright-Patterson AFB, Dayton, Ohio. (The Johns Hopkins University).

This report presents a review of research from 332 references on the perception of visual pattern or form. The report is organized into two major parts. The first part describes some of the general characteristics of the visual system which are related to the perception of patterned stimulation. The second part covers four traditional areas of form perception: form discrimination, invariance of form in perception, memory for form, and training problems. The publication period covered ranges from about 1895-1957. Both foreign and American references are given.
R 332

72. Harvard University, Psycho-Acoustic Lab. PERIODIC STATUS REPORT XXX. PERIOD COVERED: 16 MAY-15 NOVEMBER 1957. Contract Nonr-1866 (15), Proj. NR 142-201, Nov. 1957, 14pp. *Office of Naval Research.* (Psycho-Acoustic Lab., Harvard University).

This status report presents a list of personnel, an annotated bibliography of research completed, brief descriptions of work in progress, and a list of special activities of the Psycho-Acoustic Laboratory, Harvard University, for the Office of Naval Research. The period covered is from May to November 1957. A list of scientific reports beginning with mid-1954 is appended.
R 59

73. Harvard University, Psycho-Acoustics Lab. A BIBLIOGRAPHY IN AUDITION. VOLUME I. A-M. Contract Nori-76, Proj. NR 142-201, Rep. PNR-88, 1950. *Office of Naval Research.* (Psycho-Acoustic Lab., Harvard University).

This is Volume I, a bibliography of some 5500 titles. Approximately 659 of the titles are from the publication period 1938-1948; the remaining titles are pre-1938. Approximately 65-70% of the titles are American publications. The titles are indexed by author and by the following major topic headings: Reference works, Anatomical, Physiological, Psychological, Deafness, and Auditory theory.
R 5500 (approximately)

74. Harvard University, Psycho-Acoustics Lab. A BIBLIOGRAPHY IN AUDITION. VOLUME II. N-Z. Contract N5ori-76, Proj. NR 142-201, 1950. *Office of Naval Research.* (Psycho-Acoustic Lab., Harvard University).

This is Volume II, a bibliography of some 5500 titles. Approximately 659 of the titles are from the publication period 1938-1948; the remaining titles are pre-1938. Approximately 65-70% of the titles are American publications. The titles are indexed by author and by the following major topic headings: Reference works, Anatomical, Physiological, Psychological, Deafness, and Auditory theory.
R 5500 (approximately)

75. Hermans, T. G., Loucks, R. B., Checov, L., & Stern, F. ANNOTATED BIBLIOGRAPHY ON THE PSYCHOLOGICAL ASPECTS OF ORIENTATION AS THEY RELATE TO AVIATION. Contract 33-038-ac-15230, TSEAA-694-16A. Dec. 1947, 255pp. *Aero Medical Lab.,* Engineering Division, Air Materiel Command, Wright Field, Dayton, Ohio. (University of Washington).

This is an annotated bibliography of 175 scientific reports pertaining to the psychological aspects of human orientation problems. The bibliography is intended to provide engineers, aircraft instrument makers, and research personnel with information relative to the design of heading, altitude and navigation instruments.
R 175

76. Human Resources Research Office. CUMULATIVE BIBLIOGRAPHY — HumRRO AND HUMAN RESEARCH UNITS, OCAFF. Dec. 1953, 7pp. *Human Resources Research Office,* The George Washington University.

This is a listing of some 50 reports prepared by all HumRRO units through December 1953. The referenced reports vary in their security classification (Unrestricted through Secret) and pertain to training methods, leadership, morale, motivation, and psychological warfare.
R 50

77. Human Resources Research Office. BIBLIOGRAPHY OF REPORTS, HumRRO AND HUMAN RESEARCH UNITS, CONARC. May 1956, 12pp. *Human Resources Research Office,* The George Washington University.

This bibliography lists approximately 98 technical and research reports issued through 31 December 1955 from the Human Resources Research Office, Human Research Units, and the Continental Army Command. Both classified and unclassified reports are included.
R 98

78. Human Resources Research Office. BIBLIOGRAPHY OF REPORTS. 1956 SUPPLEMENT. March 1957, 5pp. *Human Resources Research Office,* The George Washington University.

This bibliography supplements the cumulative bibliography of reports issued in May 1956 by the Human Resources Research Office. Approximately 25 research and technical reports have been added to the 1956 bibliography.
R 25

79. Institute for Social Research. PUBLICATIONS OF THE INSTITUTE FOR SOCIAL RESEARCH. Fall 1955, 23pp. *Institute for Social Research,* University of Michigan.

This bibliography contains over 500 titles representing publications of the Staff of the Institute for Naval Research (University of Michigan) through 1955. The listed references are classified under such topics as: Research Methodology, Basic Research and Theory in Group Dynamics, Detroit Area Study, Economic Behavior, Human Relations and Naval Organization, etc.
R 500 ((approximately)

80. Joint Services Steering Committee for the Human Engineering Guide to Equipment Design. TENTATIVE BIBLIOGRAPHY ON WORK AND FATIGUE. Contract Nonr-1268(01), March 1954, 54pp. *Office of Naval Research.* (San Diego State College Foundation).

81. Katchmar, L. T., Whittenburg, J. A., & Weiss, E. C. REVIEW OF THE LITERATURE ON MENTAL WORK AND SUSTAINED VIGILANCE. Proj. DA-49-007-MD-222 (O.I. 19-52, Tech. Rep. 8, March 1952, 12pp. *Army Medical Research and Development Board,* Office of the Surgeon General, Washington, D.C. (University of Maryland).

This report presents a critical review of the literature on mental work and sustained vigilance (attention). The main emphasis is placed on the methodology employed and studies related to behavior decrement. The problem of definitions is treated, followed by review of mental work and factors of sleep deprivation, blocks and errors, and muscular tension. Experimental studies on attention are grouped under three headings: adequacy of attention, secondary changes, and breaking strain.
R 55

82. Kelemen, G. FENESTRATION OF THE LABYRINTH: A BIBLIOGRAPHY. PNR-143, Feb. 1954, 18pp. *Psycho-Acoustic Lab.,* Harvard University.

This bibliography of some 390 titles extends two earlier bibliographical articles which appeared in the *Laryngoscope,* 1948, *58,* 74-85; 1949, *59,* 200-202. There are no titles in this listing more current than 1946. The references cover both foreign and domestic periodicals.
R 390

83. Kidd, J. S., & Kraft, C. L. RESEARCH ON HUMAN ENGINEERING ASPECTS OF AIR TRAFFIC CONTROL. Contract AF 33(616)-3612, Proj. 7192, Rep. 6, Dec. 1957, 16pp. *Wright Air Development Center,* ARDC, Wright-Patterson AFB, Dayton, Ohio. (The Ohio State University Research Foundation).

This sixth quarterly progress report summarizes the work completed or current on the research project, Human Engineering Aspects of Air Traffic Control (ATC). Progress is reported on six aspects of the research program: operational analyses of existing ATC systems; systems, research on simulated ATC operations; technical studies and supporting basic research; theoretical formulations; design and development of research equipment; liaison activities. A bibliography of 30 reports is also included.
R 30

84. Krogman, W. M. A BIBLIOGRAPHY OF HUMAN MORPHOLOGY, 1914-1939. University of Chicago.

This bibliography of human morphology covers the literature from 1914 to 1935 with some references to classic material prior to 1914 included. The material is classified and arranged under the following topics: method in physical anthropology, osteology, races of man, prehistory of human craniology, teeth, human heredity, nervous system, myology, blood, hair dermatoglyphics (hand and foot), studies in phylogeny, soft parts, body type, and growth.
R 11,375 (approximately)

85. Loring, J. C. G. SELECTED BIBLIOGRAPHY ON THE EFFECTS OF HIGH-INTENSITY NOISE ON MAN. *J. Speech and Hearing Disorders,* Monograph Supplement 3, Jan. 1954. 38pp. Contract N5ori-76, T.O. 10, PNR-140. *Office of Naval Research.* (Psycho-Acoustic Lab., Harvard University).

This bibliography, in part, is intended as a supplement to the bibliography by Kryter (The Effects of Noise on Man. *J. Speech and Hearing Disorders,* 1950, Monogr. Suppl., 95pp) and contains 741 titles which have been classified by the author under the topics of: Deafening Effects of Noise, The Effects of Noise on Animals, The Effects of Blast, Effects on Communications, Aural Protective Devices and Preventative Measures, Effects on Human Behavior, Physiological Effects, Measurement and Reduction of Noise (Suggested Standards for Noise

Control) and Noise Fields for Engines (Including Jet Engines), and General References on Noise.
R 741

86. McBride, Patricia I., Johannsen, Dorothea E., & Wulfeck, J. W. THE EFFECT OF PRE-EXPOSURE ON DARK ADAPTATION: AN ANNOTATED BIBLIOGRAPHY. June 1955, 69pp. Executive Secretariat, *Armed Forces-NRC Vision Committee, University of Michigan.* (Tufts University).

This bibliography summarizes research concerned with the effects of different pre-exposure variables upon subsequent dark adaptation. Only those parts of a study are included in which such pre-exposure effects are described. Coverage is comprehensive through the spring of 1954. For ease and accuracy in comparing studies, the format is partially tabular with results given in summary form.
R 69

87. McCollom, I. N., & Chapanis, A. A HUMAN ENGINEERING BIBLIOGRAPHY. Contract Nonr-1268(01), Proj. NR 145-075, Nov. 1956, 128pp. *Office of Naval Research.* (San Diego State College Foundation).

This is a bibliography of 5666 references in the area of human engineering, distributed over 16 major areas as follows: general references, methods, facilities and equipment, 701; man-machine systems, 266; visual problems, 1411; auditory problems, 231; speech communication, 338; other sensory input channels, 107; comparison and interaction among sensory input channels, 86; the design of controls and integration of controls with displays, 145; control systems, 202; design and layout of workplaces, equipment and furniture, 180; body measurements and movements, 279; higher mental processes, 98; simulators and proficiency measuring devices, 280; environmental effects on human performance, 949; behavioral efficiency, fatigue and human capacity, 319; operator characteristics for special jobs, 73.
R5666

88. The Ohio State University, Laboratory of Aviation Psychology. LIST OF PUBLICATIONS, 1950-1957. 1957, 6pp. *Aviation Psychology Lab.,* The Ohio State University.

This bibliography lists 71 references to research studies carried out at the Laboratory of Aviation Psychology, The Ohio State University. The references are listed chronologically from 1950 through 1957.
R 71

89. San Diego State College Foundation. BIBLIOGRAPHY — COMPARISON AND INTERACTION AMONG SENSORY INPUT CHANNELS. Contract Nonr-1268(01), March 1955, 17pp. *Office of Naval Research.* (San Diego State College Foundation).

This is a bibliography on the comparison and interaction among sensory input channels. Primary sources are journals published between 1934-1954 with a few references to book chapters. Some foreign language references are included in the 245 titles.
R 245

90. San Diego State College. TENTATIVE BIBLIOGRAPHY ON WORK AND FATIGUE. Contract Nonr-1268(01), March 1954, 54pp. Joint Services Steering Committee for the Human Engineering Guide to Equipment Design, *San Diego State College.*

This bibliography on work and fatigue lists 788 titles from journals published in the United States and foreign countries. Accompanying each reference is the year and abstract number in the *Psychological Abstracts.* The time period covered is from approximately 1937 through 1953.
R 788

91. Stumpers, F. L. A BIBLIOGRAPHY OF INFORMATION THEORY (COMMUNICATION THEORY-CYBERNETICS). Signal Corps Contract No. DA 36-039-sc-100, Proj. No. 8-102B-o. Department of the Army Proj. 3-99-10-022, Jan. 1953, 46pp. *Research Lab. of Electronics.* (Massachusetts Institute of Technology).

This bibliography lists over 900 references generally relevant to Information Theory. Of special interest to human factors specialists are several hundred references listed under such subject headings as: Speech, Hearing, Vision, Linguistics, Semantics, Cybernetics and the Nervous System, Human Engineering, Group Communication, and Optics.
R 900 (approximately)

92. Whittenburg, J. A., & Weiss, E. REVIEW OF THE LITERATURE ON OLFACTORY SENSITIVITY AS AN INDICATOR OF SYSTEMIC FATIGUE. Proj. DA-49-007-MD-222 (O.I. 19-52), Tech. Rep. 6, April 1952, 12pp. *Army Medical Research and Development Board,* Office of the Surgeon General. (University of Maryland).

This report reviews the literature on olfaction with particular emphasis on methodology. Primary problems encountered in research are dealt with first, followed by a consideration of conditions that alter sensitivity and an evaluation of some techniques and apparatus commonly used: Zwaardemaker alfactometer, the Elsberg "blast" technique, the Wenzel "stream"

technique, Foster's olfactorium and dirhinic stimulator. The problem of a desirable technique for investigating the effects of systemic fatigue on olfactory sensitivity is discussed.
T.R 24

93. Williams, R. H., Ed. HUMAN FACTORS IN MILITARY OPERATIONS. Tech. Memo. ORO-T-259, Jan. 1954, 406pp. Department of the Army. (Operations Research Office, The Johns Hopkins University).

This is ". . . an analysis of human factors in military operations, with emphasis on the socio-psychological system of factors." Literature is reviewed and summarized for the following topics: the American community, some aspects of training, a problem in human engineering, emotional factors in combat, and group organization and dynamics. Recommendations are made for manpower policies, and the need for further research is discussed.
T.R 413

INDUSTRIAL SOURCES

94. American Power Jet Company. HUMAN ENGINEERING FACTORS AFFECTING ARCTIC AIRCRAFT MAINTENANCE DATA SOURCES AND PROJECT BIBLIOGRAPHY. Proj. 7957-1, Tech. Note AAL-TN-57-12, Dec. 1957, 66pp. *Arctic Aeromedical Lab.*, Alaskan Air Command, Ladd AFB, Alaska. (American Power Jet Company, Ridgefield, N. J.)

This is a bibliography of 566 items on human engineering factors affecting arctic maintenance. The references cover nine areas such as: aircraft maintenance experience—aircraft; aircraft maintenance experience — ground handling equipment; cold weather tests and functional evaluations; arctic facilities; human engineering —arctic and general; the psychology and physiology of man in the cold; etc. The publication period extends from about 1940 through 1956. Both classified and unclassified items are included.
R 566

95. Baker, Alma S. BIBLIOGRAPHY OF INFORMATION THEORY. Mar. 1953, 54pp. *Ratheon Manufacturing Company*, Equipment Engineering Division, Documents and Research Information Section, Newton, Mass.

This report is a compilation of 462 references on general information theory, exclusive of speech and television information theory. The titles, which cover both American and foreign publications from approximately 1928 through 1952, also include those references on noise, modulation, bandwidth theory, entrop, and mathematics which were considered basic to the development of information theory. A list of periodical abbreviations and a subject index are also included.
R 462

96. Bevan, W., & Patton, R. M. SELECTED BIBLIOGRAPHY: FATIGUE, STRESS, BODILY CHANGE, AND BEHAVIOR. Contract AF 33(616)-3745, ORD Rep. 108, Dec. 1956, 59pp. Military Operations Research Engineering Division, *Lockheed Aircraft Corporation*, Marietta, Ga.

This is a selected bibliography of papers in the general areas of fatigue, stress, bodily changes, and behavior. The period covered is 1946-1956. The selection of items was based upon the needs of an experimental investigation of aircrew fatigue associated with relatively long confinement within the flight station of an advanced design airplane. A topical index is provided for general papers and reviews, fatigue as an independent variable affecting performance, and as a dependable variable, stress as an independent and dependent variable, and the physiology of fatigue and stress.

97. Bolt Beranek and Newman Inc. CAPABILITIES AND LIMITATIONS INVESTIGATION OF LONG-RANGE PUBLIC ADDRESS EQUIPMENT: I. LITERATURE SEARCH AND PRELIMINARY THEORETICAL ANALYSIS, 15 JULY 1954-31 MAY 1955. Contract DA-36-039 SC-64503, DA Proj. 3-99-12-022, SC Proj. 132B, Rep. 312, Final Rep., 126 pp. *Bolt Beranek and Newman Inc.*, Cambridge 38, Mass.

As part of an initial report of research to determine the capabilities and limitations of long-range public address equipment for the transmission of intelligible speech under varied conditions, a literature survey covering 544 references is presented. Discussion of the literature is covered in three sections with individual bibliographies: propagation of sound through the atmosphere, factors affecting the intelligibility of speech (level, bandwidth, masking, distortion, etc.), and experimental data and variability.
G.I.R. 544

98. Coles Signal Laboratory. A BIBLIOGRAPHY OF SPEECH COMMUNICATION IN NOISE. Contract DA-36-039-sc-64469, Proj. 132B, 843D, Order 94-

PH-55-91 (4307), Jan. 1955, 224pp. Department of the Army. (Radio Corporation of America, Shoran and Specialties Engineering, Camden, N. J.)

This is a bibliography of items especially chosen for their pertinence to the subject of speech communication in noise. The approximate time period covered is from 1930-September 1954. The items are classified as follows: general; architectural acoustics; books and bibliographies; the ear and hearing; applied acoustics, instruments and apparatus; musical instruments and music; noise; speech and singing; ultrasonics; waves and vibrations; underwater sound; personnel and training; psychology and human engineering.
R 2700 (approximately)

99. Dennis, W. AGE AND BEHAVIOR. A SURVEY OF THE LITERATURE. Proj. 21-020-0005, Rep. 1, May 1953, 146pp. *School of Aviation Medicine,* Randolph AFB, Tex. (American Institute of Research, Pittsburgh, Penn.).

This is a selective review of studies dealing with the relationships between age and behavior which concerns itself primarily with information pertaining to job fitness as a function of age and the research techniques and needs in this area. Studies are presented in the general areas of: (1) social behavior and personality (e.g., resistance to change, reading interests, etc.); (2) mental abilteis and mental achievements (e.g., studies of learning, memory, intelligence, etc.); (3) psychomotor abilities and skills (e.g., strength, reaction time, accidents, etc.); (4) sensory and perceptual abilities (e.g., vision, audition, etc.).
T.G.R 193

100. Kryter, K. D. THE EFFECTS OF NOISE ON MAN. *J. Speech & Hearing Disorders,* 1950 Monograph Supplement 1, 95 pp. (Central Institute for the Deaf, St. Louis, Mo.).

This report contains critical reviews of the literature on the topics of: Effects of Noise and Behavior, 122; Deafening Effects of Noise. 137; and Effects of Noise on Communication by Speech, 264. In addition 106 references are cited in Measurement and Reduction of Noise.
R 629

101. Miller, J. G., Bouthilet, Lorraine, & Eldridge, C. A BIBLIOGRAPHY FOR THE DEVELOPMENT OF STRESS-SENSITIVE TESTS. Contract DA-49-083-osa-611, PRB Tech. Res. Note 22, Oct. 1953. *Psychological Research Associates,* Washington, D.C.

This is an 1862-item bibliography compiled as part of a research program on the development of stress-sensitive tests. Included are references in such areas as: measurement and effects of stress, studies of anxiety and anxiety-measurement, effects of extreme environmental conditions, studies of combat fatigue and war neuroses, and physiological stress reactions. Most references are drawn from scientific journals, mainly after 1930. A second part of this review presents abstracts of 118 of these references, selected because of their more direct relevance to the rsearch problem.
R 1862

102. Novak, J. W., Teeple, J. B., & Sleight, R. B. SLEEP DEPRIVATION AND TASK PERFORMANCE: AN ANNOTATED BIBLIOGRAPHY. DA-36-039-SC-67912, August 1957, 18pp. *Applied Psychology Corporation,* Washington 1, D.C.

This is an annotated bibliography on sleep deprivation. Emphasis is placed on those studies that assess the effects of sleep loss on task performance and which provide quantitative data. Several types of sleep loss are covered: acute sleep loss, chronic sleep loss, and interrupted sleep. The studies are outlined in terms of purpose, materials and procedures, and results and conclusions.
R 21

103. Snodgrass, F. T., Teeple, J. B., & Sleight, R. B. EFFECTS OF FATIGUE ON PERFORMANCE OF VISUAL-MOTOR TASKS: AN ANNOTATED BIBLIOGRAPHY. DA-36-039-SC-67912, August 1957, 27pp. *Applied Psychology Corporation,* Washington 1, D.C.

This is an annotated bibliography on the subject of fatigue. The studies selected are primarily concerned with the relation of fatigue that may be experienced under normal operating conditions to the performance of complex visual-motor tasks. Some studies deal with fatigue resulting from task performance. The abstracts are presented in terms of purpose, material, and procedures, results and conclusions.
R 31

104. Tiedeman, D. V., Scheffler, I., & Starr, J. PRODUCTION, SPEED, ACCURACY AND SAFETY IN THE MAINTENANCE OF LONG-RANGE AIRCRAFT: A CONCEPT AND AN ANNOTATED BIBLIOGRAPHY. Contract AF 41(657)-77, ERC Proj. 45, August 1957, 111pp. *Personnel Research Lab.,* AFPTRC, ARDC, Lackland AFB, Tex. (Educational Research Corporation, Cambridge, Mass.).

This report reviews evidence from the literature "relevant to the use of differential standards of personnel quality in assignment to positions differing in requirements for speed and accuracy

of performance". Attention is focussed upon activities involved in the maintenance of long-range aircraft. Major topics are: work-pattern, physical environment, social environment, and man. The period of time covered by the literature is from 1927 through 1956 with the primary bibliographical source the *Psychological Abstracts*. An annotated bibliography (190 references) is presented separately from this report. Appendices contain various citations that were not used and a memorandum report on human engineering considerations in maintenance of nuclear-powered equipment.
T.I.R 380

FOREIGN SOURCES

105. Advisory Group for Aeronautical Research and Development. COLLECTED PAPERS ON AVIATION MEDICINE. 1955, 209pp. *Advisory Group for Aeronautical Research and Development,* North Atlantic Treaty Organization, Paris, France.

A series of 18 papers in English, French and Italian presented at various Aeromedical Panel Meetings of AGARD, is included. The papers relate to various aspects of aviation medicine, such as: heterophoria, night vision, color vision, effects of high intensity noise, cold-induced tissue injury, abrupt deceleration, physiological requirements of pressure cabins, layout of aircraft cockpits, arctic survival problems, anoxia, etc.
T.G.I.R 95

106. Anon. CUMULATIVE BIBLIOGRAPHY. May 1957, 20pp. *Institute for Perception RVO-TNO,* National Council for Applied Scientific Research in the Netherlands.

The topics covered in this cumulative bibliography (1947-1957) are primarily in the area of vision, with some few in audition. Journal articles, technical reports and memoranda from the Institute are included in the 110 titles listed. Brief annotations accompany each item.
R 110

107. Applied Psychology Research Unit, Staff. HUMAN PERFORMANCE REFORTS, LIST 3. THE DESIGN OF EQUIPMENT FOR HUMAN USE. Summer, 1957, 17 pp. *Applied Psychology Research Unit,* Medical Research Council, Cambridge, England.

Brief summaries of human performance reports from this research unit are reported. They are grouped under the following general headings: general (design of equipment), seeing, hearing, deciding, thinking and learning, remembering, and moving.
R 20

108. British Aeronautical Research Council. LIST OF PUBLICATIONS BY THE AERONAUTICAL RESEARCH COUNCIL. British Government Publications, Sectional List No. 8, March 1946, 79pp. *British Aeronautical Research Council,* England.

This bibliography lists the published reports of the British Aeronautical Research Council from approximately 1915 to 1946. The 2017 titles are classified under 41 headings, such as: accidents, aerodynamics, aerofoils, aeroplanes, engines, instrumentation and apparatus, meteorology, propellers, seaplanes, stability, wind tunnels, etc.
R 2017

109. Gowdey, C. W., & Pearce, J. W. A SELECTED BIBLIOGRAPHY OF THE OPEN LITERATURE ON AVIATION MEDICINE, 1945-1955. DR 97, July 1955, 59pp. *Defence Research Board,* Department of National Defence, Canada.

This is a selected bibliography of the open literature on topics in or related to Aviation Medicine. Emphasis is placed on basic rather than applied research in order to serve as a guide to more important problems and recent experimental findings in the field. Coverage is restricted to those journals which are likely to be available in a medical library of average size with no references to technical or project reports. These topics receive special emphasis: air sickness, altitude effects, anoxia and hypoxia, blood gases and respiratory physiology, decompression aeroembolism, explosive decompression, hyperventilation, negative and positive G, oxygen toxicity, pressure breathing, stress and fatigue, and vestibular apparatus.
R 724

110. Mackworth, N. H. HUMAN PERFORMANCE REPORTS, LIST 2. Autumn 1956, 17pp. *Applied Psychology Research Unit,* Medical Research Council, Cambridge, England.

This is a 1956 bibliography of human performance reports from the Applied Psychology Research Unit, England. Summaries of 17 studies are organized around the topics of seeing, hearing, thinking, moving, working, training, and surroundings.
R 17

111. Ministry of Supply. BIBLIOGRAPHY OF INFORMATION ON SERVOMECHANISMS AND RELATED SUBJECTS. Nov. 1950, Addendum, Sept

1955, 241pp. Technical Information Bureau, *Ministry of Supply,* England.

This is an extensive annotated bibliography of information on servomechanisms and other related subjects. It includes such general aspects as the following: theory, design and analysis of control systems and instruments, design of equipment in tracking, information concerned specific types of controls, etc. An author index is included.
R 800 (approximately)

112. Noro, L., & Heikel, A. PART I. PUBLICATIONS IN YEARS 1940-1950. PART II. PUBLICATIONS OF THE INSTITUTE OF OCCUPATIONAL HEALTH IN YEARS 1951-1957. 67pp. *Institute of Occupational Health,* Helsinki, Finland.

This bibliography lists publications — original investigations, review articles, popular articles, travel reports and congresses, annual reports of various related organizations—on occupational health covering the period 1940 to 1957 in Finland. Topics covered are: general aspects, industrial toxicology, pneumoconiosis, organic dust, occupational dermatitis, noise and vibration, industrial ophthalmology, occupational physiology, occupational psychology, and accidents. A brief bibliography of periodicals on occupational health and safety in Finland is included.
R 1017

113. Whiteside, T. C. D. THE PROBLEMS OF VISION IN FLIGHT AT HIGH ALTITUDE. London: Butterworths Scientific Publications, 1957, 162pp. AGARDOGRAPH 13. *Advisory Group for Aeronautical Research and Development,* North Atlantic Treaty Organization, Paris, France.

This book deals specifically with visual problems of flight in the stratosphere or upper limits of the troposphere. Following an introduction a series of investigations are reported on: (1) effects of changes in intensity and spectral distribution of sunlight at high altitudes; (2) physiological changes affecting visibility of objects inside the cockpit; and (3) physiological factors affecting air-to-air visibility. A discussion of the problems of glare (contrast measurements), discomfort and anoxia, and search (empty field myopia, accommodation, fixation pattern, other problems of empty visual field) presents a comprehensive view of the problem as a whole.
T.G.I.R 98

ADDENDUM

The editors, with the consent of the authors, have added a few references which appear to deserve inclusion in this bibliography for the sake of completeness.

114. Arima, C. L. BIBLIOGRAPHY OF HUMAN RESOURCES REPORTS, 1947-1957, Part "A", March, 1958, 11 pp. Directorate of Scientific Information Service, Defence Research Board of Canada, Ottawa, Ontario.

Unclassified reports, publications and theses resulting from Defence Research Board projects in the fields of human resources and human engineering for the period from 1947-1957, are listed. The bibliography is divided into two parts: Defence Research Board Establishments, 94 items; Universities, 79 items.
R 173

115. Berens, Conrad, & Sheppard, L. Benjamin. Vols. I & II; Berens, Conrad, Sheppard, L. Benjamin, and Bickerton, John H. Vols. III & IV. ABSTRACTS ON MILITARY AND AVIATION OPHTHALMOLOGY AND VISUAL SCIENCES, Vols. I, II, III, IV. *The Biological Sciences Foundation, Ltd., Washington, D.C.* Vol. I Published 1953, 539 pp. Covers period through 1940. R 1262. Vol. II Published 1953, 425 pp. Covers period 1941 to 1945 inclusive. R1095. Vol. III Published 1957, 466 pp. Covers period 1946 to 1948. R1713. Vol. IV Published 1957, 510 pp. Covers period 1949 to 1951. R1654.

These volumes attempt to compile all reference on military and aviation opthalmology and closely related subjects. General references in ophthalmology are not covered except where they cover the diagnosis of certain eye diseases, and the treatment of eye injuries. The major subject headings are arranged alphabetically, e.g. acceleration, accidents, accommodation... to visual fields, visual reaction time.

116. Harvard University, Psycho-Acoustic Lab. BIBLIOGRAPHY ON HEARING, 1955, 599 pp. *Harvard University Press,* Cambridge, Mass.

This is an enlargement of references 73 and 74 in book form which contains all the same references plus new fields of interest such as information theory as well as later subject matters.
R 10,000 (approximately)

117. Moyer, June. A BIBLIOGRAPHY OF SPEECH COMMUNICATION IN NOISE. SUPPLEMENTARY REPORT "A". January 1955, 224 pp. Signal Corps, Contract DA-36-039-SC-64469. *Shoran and Specialties Engineering, Engineering Products Division.* RCA, Camden, N.J.

This report contains about 2900 references. A number of these references pertain to human factors. No annotations are given. The material in this bibliography is classified for the most part according to the Journal of the Acoustical Society of America Classification System. Two supplementary subject fields, "Personnel and Training" and "Psychology and Human Engineering" have been added. References in Section 4, The Ear and Hearing; Section 7, Noise; Section 9, Speech and Singing; and Section 13, Underwater Sound, should be of greatest interest to human factors specialists. *R 2900* (approximately)

BOOK REVIEW

HUMAN ENGINEERING by Ernest J. McCormick

McGraw-Hill Book Co., Inc., New York, 1957. xi + 467 pp. Price $8.00.

This book fulfills a need that has been strongly felt by human factors personnel to have a text that brings the classic Chapanis, Garner, and Morgan *Applied Experimental Psychology* up to date since the latter's publication in 1949. It is well written and approaches the subject from an eclectic viewpoint at a level which makes it suitable as an introductory text as well as a reference work for the "fundamentals" of the field.

The text includes sixteen chapters over the range of topics from displays and controls to environments and work space arrangement. The last three chapters emphasize a "systems" rather than a "component" approach and as such they contribute a timely and significant addition to the text material available to the general public.

It must be recognized that the rapid growth of the human factors field is such that no one text could hope to cover the entire subject in detail. However, this reviewer felt that several areas, such as visual presentation of information by means other than dials (e.g. radar), vigilance, biological effects of ionizing radiation, dynamic characteristics of the human operator, and other major topics of current interest to practicing human factors personnel were conspicuous by their virtually complete absence. Also the level of presentation of many topics, e.g., Chapter 9, "Atmospheric Conditions", Chapter 10, "Body Orientation and Acceleration Forces" could have been improved considerably in its sophistication by taking more advantage of quantitative analysis methods which have been available for some time.

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